Acta Agronomica Hungarica

VOLUME 37, NUMBERS 1–2, 1988

Akadémiai Kiadó, Budapest

ACTA AGRONOMICA HUNG. HU ISSN 0238–0161

// ACTA AGRONOMICA

A QUARTERLY OF THE HUNGARIAN ACADEMY OF SCIENCES

Acta Agronomica publishes papers in English on agronomical subjects, mostly on basic research.

Acta Agronomica is published in yearly volumes of four issues by

AKADÉMIAI KIADÓ

Publishing House of the Hungarian Academy of Sciences

H-1054 Budapest, Alkotmány u. 21.

Manuscripts and editorial correspondence should be addressed to

Acta Agronomica

H-1118 Budapest, P.O. Box 53

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KULTURA Foreign Trading Company

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or to its representatives abroad

Acta Agronomica Hungarica is abstracted/indexed in Biological Abstracts, Bibliography of Agriculture, Chemical Abstracts, Current Contents–Agriculture, Biology and Environmental Sciences, Excerpta Medica, Horticultural Abstracts, Hydro–Index, Plant Breeding Abstracts, Nutrition Abstracts and Reviews

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Acta Agronomica Hungarica, 37 (1–2), pp. 3–18 (1988)

Plant physiology

DYNAMICS OF NUTRIENT UPTAKE AND ABOVEGROUND PHYTOMASS IN SOME WINTER WHEAT VARIETIES AT MAJOR GROWING SITES OF HUNGARY

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(Received: 28 February 1986)

The dynamic characteristics of aboveground dry matter yield formation and nutrient accumulation in some commercially produced early and medium early winter wheat varieties were studied on the basis of observations made on large-scale farms. The great bulk of phenodynamic data on the aboveground phytomass, the accumulation of phosphorus and potassium, and all their visible characteristics can be summarized without loss of any information by using the two-subcompartment model. The new method of evaluation relying on the simulation figures and the numerical values of the model parameters is more comprehensible and leads to the following conclusions:

— the differences between early and medium-early winter wheat varieties in the process of shoot production and nutrient (P, K) accumulation are expressed particularly in the earlier acceleration and earlier maximum of accumulation in the early varieties;

— the time functions for shoot mass and nutrient accumulation can be placed in two groups irrespective of the maturity group: in the reflux and reflux-free type of phenodynamics, respectively;

— the dynamics of phosphorus accumulation shows similarity to the course of dry matter formation more often and to a greater extent than does the dynamics of potassium accumulation;

— it can be demonstrated that the reflux character of dynamics, mostly concomitant with an increased level of K-supply, strengthens in the component turnover of winter wheat shoots in the order of dry matter formation, P-accumulation and K-accumulation;

— the reflux type character of phenodynamics of the potassium quantities in plants — due to the physiologically active form of potassium — is a function of precipitation conditions in the period following flowering, and also a feature characteristic of variety and agro-ecological district;

— the medium and above-medium level of potassium supply in the soil promotes a more frequent occurrence of reflux type dynamics;

— in this way, and considering its extent, the potassium reflux cannot be neglected when adjusting the potassium supply of soil to the phenophases of winter wheat.

Keywords: Winter-wheat, nutrient uptake, dry matter accumulation.

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Introduction

The analysis of nutrient accumulation in plants is a classical but invariably important field of plant nutrition research. A precondition of discovering the total and periodical mineral element demand of the plant is to measure the nutrient uptake as accurately as possible and to describe the dynamic rules of nutrient accumulation. A detailed examination of mineral accumulation under various agro-ecological (climatic, soil-, etc.) conditions helps in controlling — and possibly planning the agro-ecological factors and their interactions according to our plant growing objectives with a minimum of unforeseen harmful effects upon the environment.

As known from many publications, the nutrient demand of the plant varies during its different phases of development (Knowles and Watkin 1931, Primost 1965, Kieese et al. 1968, Czuba 1969, Page et al. 1977, Kádár and Lásztity 1979).

Studies on the nutrient uptake of winter wheat started in Hungary — after foreign examples — as early as the beginning of this century (Adorján 1902). Since then research on this subject, from different points of view depending on the agro-ecological conditions, has extended and deepened all over the world. The range of nutrient elements studied has gradually widened with the improvement of analytical methods (Carpenter et al. 1952, Coic 1956, Láng 1960, Sarkadi 1966, Gregory et al. 1979, Karlen and Whitney 1980, Lásztity 1982). The sites of sample collecting range from water culture through culture pot- and field experiments to commercial crop fields (Curic 1969, Debreczeni 1971, Elek and Kádár 1978, Lásztity and Kádár 1978, Lásztity et al. 1981, Sebestyén et al. 1982). In the present work we attempt to evaluate some newly discovered phenomena of nutrient phenodynamics relying on the results of observations made under large-scale conditions.

Material and methods

From 2500 m^2 model areas of the commercial fields marked out for this purpose, plant samples with 5 replications for each were taken in 1979 on 5 dates (and in 1978 in the Mezőföld* on 11 dates) in the phenophases of tillering, shooting, earing, flowering and full maturity. Each sample contained the whole aboveground phytomass of 4 running metres. After the material had been dried and weighed the most important 12 nutrient elements were analysed, of which the accumulation of phosphorus and potassium is dealt with in this paper.

The winter wheat varieties included in the experiment are listed in Table 1, together with the sites of sample taking and their major characteristics. The capital letters mean: A = dry–cool, B = dry–warm, D = humid–warm. The designations for the climatic type of year were determined on the basis of the available heat sums of May–June, rainfall amounts of April–May, and of the soil types in the respective agroecological districts, as published in the report of the Interdepartmental Committee that assessed the agroecological potential

* Plain in Transdanubia along the Danube.

Table 1

Major characteristics of model areas in crop fields

Agro-ecological district	Code	Climatic type of year	Growing site type	Nutrient status of soil			Variety
				humus	phosphorus	potassium	
Lower Tisza region	8 (1)	A	IV	good	good	very good	Jubilejnaja 50
Lower Tisza region	8 (2)	A	III	medium	very good	medium	Jubilejnaja 50
Mezőföld	4 (1)	D	I	very good	very good	medium	Jubilejnaja 50
Mezőföld	4 (2)	D	I	very good	good	medium	Jubilejnaja 50
Tolna–Baranya hill-country	23 (1)	B	I	good	very good	very good	Jubilejnaja 50
Tolna–Baranya hill-country	23 (2)	B	II	good	good	medium	Jubilejnaja 50
Dunamenti Plain	1 (2)	B	III	good	very good	very poor	Jubilejnaja 50
Dunamenti Plain	1 (3)	B	III	medium	good	poor	Jubilejnaja 50
Dunamenti Plain	1 (1)	B	III	medium	medium	poor	Ns. Rana 2
Sopron–Vas Plain	18 (1)	B	II	good	medium	medium	Jubilejnaja 50
Sopron–Vas Plain	18 (2)	B	III	poor	good	medium	Jubilejnaja 50
Sopron–Vas Plain	18 (3)	B	II	good	medium	good	GK-3
Hajdúság	11	B	I	good	poor	good	Partizánka
Berettyó–Körös–region	12	B	I	good	good	good	Jubilejnaja 50
Duna–Tisza Interfluve table-land	2	B	I	good	medium	good	Ns. Rana 2
Central Tisza region	7	B	III	good	very good	good	Ns. Rana 2
Subalpine-region	17	B	II	good	good	good	Rannaja 12
Bácska Table-land	3 (1)	A	I	medium	good	very good	Száva
Bácska Table-land	3 (2)	A	I	good	good	medium	Száva

(Láng 1980). The categories of the soil nutrient status and the growing site types we set up on the basis of centrally fixed and nationally accepted limit values (Debreczeni 1979). The dynamics of nutrient uptake was studied with the aid of a phenomenological model (Békésy et al. 1982). The model was verified in several experiments and by a bulk of data on measurement in many commercial fields (Biczók et al. 1982a, Lásztity et al. 1982), and the results of its comparison with the *Richards-*, *Mitscherlich-*, *Gompertz–Makeham-* and *Janoschek-models* are also known (Biczók et al. 1982b).

The model describes the component turnover of the shoot-soil compartment of the soil plant-atmosphere system. It contains two subcompartments, so the accumulation in t/days is:

$$U_i = \frac{A_i}{1 + e^{-b_i(t-t_g)}} - \frac{R_i}{1 + e^{-s_i(t-t_s)}}$$

where i is an index for the characteristic to be examined; A_i a saturation value, the value of maximum accumulation, which in a given environment is proportionate to the genetic potential. R_i is the total reflux; that is, the amount of nutrient returning into the soil in the cours of senescence. The t is an independent variable representing the time in days from sowing the parameter t_g is the inflexion point of accumulation, a phenologically hidden starting point of time of the generative development; t_s is a function parameter, the inflexion point of reflux. The parameter b_i is the acceleration of uptake, and/or a quantity related with the buffer capacity of the nutrient element; while s_i is the extent of acceleration or retardation of the loss of nutrient induced by senescence. Since the very reason of using the two compartment model in this paper is to provide concise information, we are passing over expounding it in detail. Attention is, however, called to the fact that the key for the concentrated form of information is the real biological meaning of the model parameters. The time curves of component accumulation were drawn from measured data — on the basis of this model with the help of a non-linear regression programme system produced for this special purpose (Biczók et al. 1982c), and placed at the users' disposal in the computer centre of the Computer and Automation Institute of the Hungarian Academy of Sciences, on the IBM 3031 system, together with data of the 20 most important field crops. The analyses of nutrient uptake were organized by the MÉM NAK and carried out in its laboratories.

Results

The parameters of the model applied are contained in Table 2. To make a comparative analysis possible the relations between early (Rannaja 12, Novosadska Rana 2 and Száva) and medium-early (Jubilejnaja 50, GK-3, Partizánka) winter wheat varieties, and a number of growing site types were studied within a range of agro-ecological conditions characteristic of Hungary (Table 1).

Figure 1 shows the characteristics of dry matter accumulation in the variety Jubilejnaja 50 at growing site types of different quality and in various agro-ecological districts. In the figures the site of sample taking is marked with a number put in brackets after the numbers of the agro-ecological districts indicated in Table 1.

It can be seen that the aboveground phytomass at growing site type I reaches its maximum of full maturity at the (12) point of observation. At growing site type II it is again in full maturity (23/2) or earlier than this (18/1) — depending on the agro-ecological district — that the dry matter production of shoots culminates. At growing sites type III and IV in the observation place (8/1/) and (8/2/) — the highest value of aboveground phytomass of

Table

Parameters of the model

Code number of sampling site		A_i	R_i	b_i	t_g	s	t_s
8 (1)	D. mat.	23.840	14.356	0.080	198.67	0.116	217.91
	P	47.502	31.329	0.080	187.46	0.249	220.42
	K	497.060	450.310	0.080	183.00	0.161	222.69
8 (2)	D. mat.	18.359	6.304	0.080	200.02	0.277	250.27
	P	34.371	18.753	0.080	192.22	0.696	229.51
	K	528.21	448.78	0.080	192.48	0.128	230.16
18 (1)	D. mat.	9.765	1.572	0.080	212.66	0.506	261.79
	P	68.153	43.145	0.080	209.66	0.731	233.84
	K	184.58	154.58	0.080	204.44	0.722	233.56
17	D. mat.	8.24	3.213	0.074	214.47	0.333	260.39
	P	26.183	12.768	0.080	199.18	0.093	240.53
	K	73.788	59.006	0.080	193.75	0.181	230.52
18 (2)	D. mat.	11.717	5.209	0.080	205.32	0.357	254.05
	P	51.891	31.235	0.080	196.6	0.197	246.67
	K	351.81	334.88	0.080	200.82	0.151	232.70
18 (3)	D. mat.	9.764	3.335	0.080	214.02	0.216	267.93
	P	37.776	15.573	0.080	206.25	0.130	259.19
	K	201.22	188.79	0.080	206.40	0.363	235.23
12	D. mat.	13.101	—	0.077	211.80	—	—
	P	70.948	—	0.045	254.36	—	—
	K	210.24	161.22	0.080	201.57	0.959	225.04
7	D. mat.	16.463	—	0.078	227.69	—	—
	P	79.413	—	0.080	252.45	—	—
	K	134.25	—	0.066	201.98	—	—
11	D. mat.	11.634	—	0.071	216.76	—	—
	P	55.178	—	0.056	253.46	—	—
	K	98.778	60.482	0.074	192.20	0.621	232.27
2	D. mat.	19.201	9.616	0.073	233.90	0.540	250.63
	P	36.807	13.614	0.051	216.13	0.050	251.00
	K	269.77	190.40	0.052	213.94	0.999	249.77
1 (1)	D. mat.	9.566	—	0.078	217.99	—	—
	P	30.449	—	0.040	221.78	—	—
	K	164.50	92.290	0.080	202.72	0.232	235.66
3 (1)	D. mat.	10.119	—	0.073	213.16	—	—
	P	19.712	—	0.043	204.23	—	—
	K	237.57	137.82	0.080	202.73	0.561	244.62
3 (2)	D. mat.	14.189	6.647	0.080	223.71	0.483	250.49
	P	40.566	23.423	0.080	219.69	0.228	243.73
	K	300.74	227.62	0.080	218.74	0.262	241.83
23 (1)	D. mat.	12.418	—	0.077	238.27	—	—
	P	45.721	—	0.074	236.92	—	—
	K	83.104	—	0.079	209.43	—	—
23 (2)	D. mat.	11.755	—	0.080	237.12	—	—
	P	43.156	—	0.079	234.67	—	—
	K	76.462	56.376	0.080	215.08	0.272	255.21
1 (2)	D. mat.	12.997	—	0.080	239.13	—	—
	P	73.799	—	0.053	250.05	—	—
	K	77.204	46.511	0.080	215.56	0.325	256.97
1 (3)	D. mat.	12.102	—	0.078	232.79	—	—
	P	38.095	—	0.050	220.95	—	—
	K	145.95	115.83	0.078	219.35	0.331	257.87
4 (1)	D. mat.	11.273	—	0.032	265.17	—	—
	P	19.354	—	0.073	273.16	—	—
	K	47.260	—	0.030	263.59	—	—
4 (2)	D. mat.	10.496	—	0.035	263.03	—	—
	P	18.857	—	0.072	272.25	—	—
	K	61.367	—	0.033	266.69	—	—

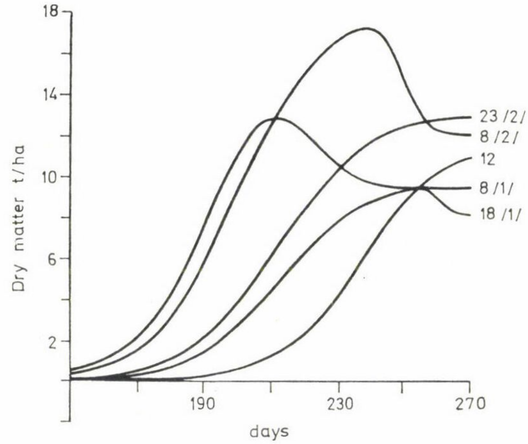

Fig. 1. Curves for the phenodynamic character of aboveground dry phytomass formation in the winter wheat variety Jubilejnaja 50 in various agro-ecological districts

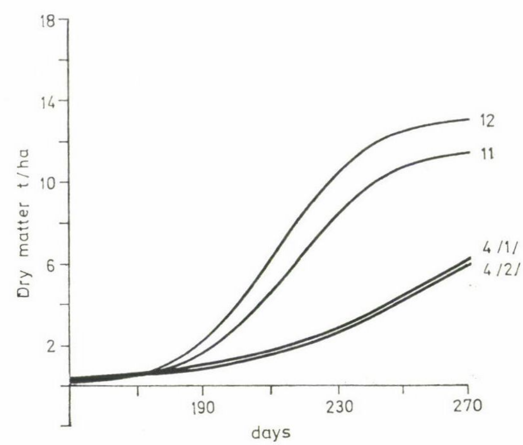

Fig. 2. Aboveground dry matter accumulation of medium-early winter wheat varieties at growing site I in different agro-ecological districts

winter wheat appears in earlier phenophases, due to a reflux in the given cropyear.

These statements can be regarded as of general validity only after further detailed investigations if at all. In Figure 2 the results of a study of the effect of agro-ecological factors on the dynamics of dry matter accumulation in a medium-early variety at growing site type I are seen. The differences between agro-ecological districts in both the amount and rate of accumulation are remarkable, so much so that even the advantages of the more favourable (humid–warm, D) type of climate in 1978 remain hidden at points (4/1/)

and (4/2/). At the same time, within the same agro-ecological district (4/1/, 4/2/), and in those near to one another (11, 12) the P-status of the soil differentiates the total dry matter production in the case of medium early winter wheat varieties (Tables 1 and 2).

Figure 3 shows the influence of the agro-ecological district at the growing site type III of low productivity as studied again with the variety Jubilejnaja 50. The descent of the curves clearly indicates that the differences in quantity and the reflux processes of stands (8/2/) and (18/2/) are very pronounced in the given phenophases. Furthermore, the agro-ecological districts show differences in the character of dynamics, made all the more remark-

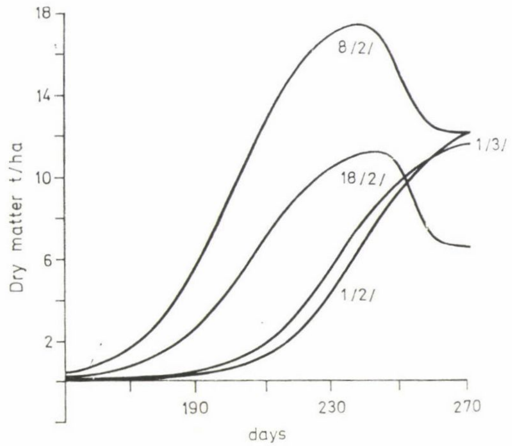

Fig. 3. Aboveground dry matter accumulation of medium-early winter wheat varieties at growing site III in different agro-ecological districts

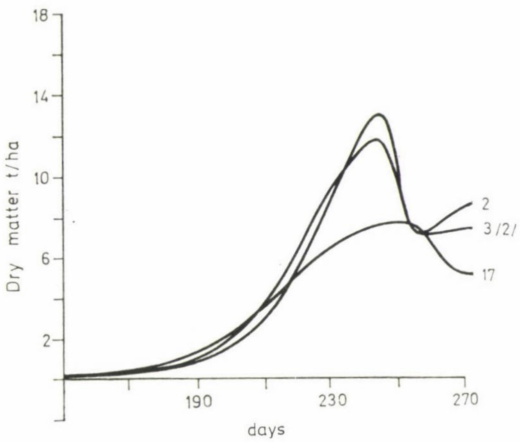

Fig. 4. Aboveground phenodynamics of dry matter production followed by reflux in early winter wheat varieties

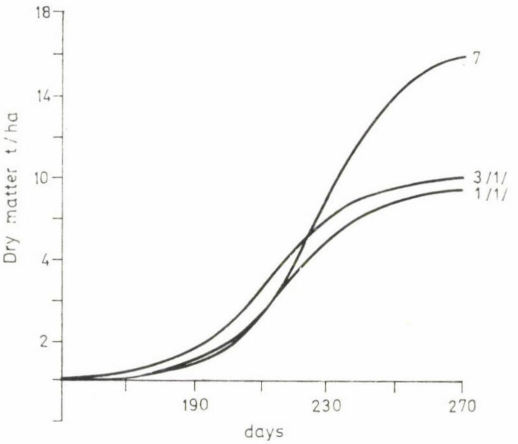

Fig. 5. Phenodynamics of reflux-free dry matter production in early winter wheat varieties

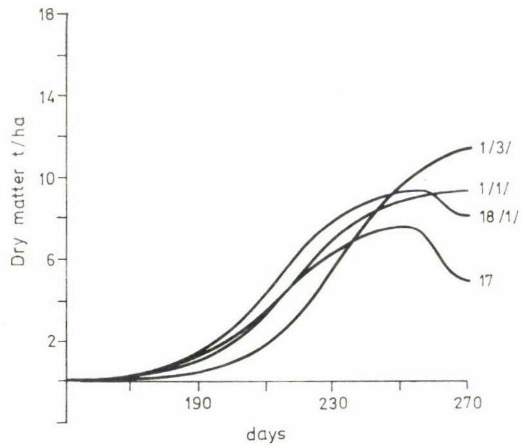

Fig. 6. Phenodynamical comparison of aboveground dry phytomass in medium-early and early winter wheat varieties

able by the fact that the level of P-supply, which often is of great importance for cereals, is uniformly favourable at those points. At the same time, it is interesting that at points (8/2/) and (18/2/) the higher intensity of dry matter formation seems to relate to a better K-supply (Table 1). Here we call attention to another fact — to be seen later in the case of the other fields —, namely that the onset of reflux — which is nothing other than the fulfillment of the $R_i > 0$ condition is (at a medium or above-medium level of P-supply) linked with a medium or above-medium level of K-supply; while in the case of a poor potassium status, it never occurs.

In Figure 4 the dynamics of dry matter accumulation in early varieties under different ecological conditions can be seen. As a result of reflux the maxima of accumulation fell to the period preceding full maturity. The only differences among the districts appeared in the rates of reflux.

The dynamics of dry matter accumulation in the early varieties is represented for those agro-ecological districts too where reflux did not occur, whereby the aboveground phytomass reached its maximum at the time of full maturity (Fig. 5). A remarkable difference was found in the intensity of accumulation that can be explained on the basis of the nutrient status categories of Table 1. Moreover, the dry matter formation followed the order of nutrient supply so strictly that even the influence of the site was oppressed.

That is how the decreasing order seen in Fig. 5: 7 (growing site type III), 3/1/ (growing site type I) and 1/1/ (growing site type III) developed.

In Figure 6 the medium-early winter wheat varieties are compared with the early ones at growing sites of the same quality and in agro-ecological districts near each other. The figure shows the dynamics of dry matter formation with and without reflux, depending on the district. The quantitative differences at points (1/3/) and (1/1/) in the reflux-free dynamics of the aboveground phytomass of the varieties, as measured on the Plain by the Danube, probably resulted from the different levels of nutrient supply. In two agro-ecological districts near each other in the western borderland of Hungary, the intensive phase of dry matter accumulation was followed by reflux. The early variety Rannaja 12 (17) is preceded in development by the medium-early Jubilejnaja 50 (18/1). This fact, though inconsistent with either the growing site types or the nutrient status categories, is not surprising when the April–May amount of rainfall (105 mm) in the field of Jubilejnaja 50 is considered. In the same period of 1979, a year of the dry–warm climatic type, Rannaja 12 received a mere 30 mm of rainfall.

Since any further calculation is based on dry matter yield determinations, prior to analysing the phenodynamics of nutrient uptake let us examine the adequacy of a model adaptation from the crop-production viewpoint. On the iterative approximation of the A_i values, a higher dry aboveground phytomass yield than expected on the basis of the given climatic type of year, genetic soil type and agro-ecological district was not found in 9 cases. In these cases a very close correlation, characterized by *Bravais*' correlation coefficient of $r = 0.925$, can be pointed out between the values of the two kinds of estimation. This means that the agreement between the forecasting methods applied on assessing the agro-ecological potential of Hungary (Láng et al. 1983) and the iterative procedure is 85.6% in 9; 75.6% ($r = 0.869$), in 6; and 70% ($r = 0.837$) in 4 cases. In the latter 6 and 4 cases our estimate for the value of A_i was 5.8 and 14.5, that is about 30% higher, respectively, than the values obtained by the method cited. (In the course of the comparative analysis the grain/straw ratio taken into consideration was 1 : 1 for the early and 1 : 1.2 for the medium-early winter wheat varieties.) Since in 4 cases the maximum dry matter yields measured at points (8/1/), (8/2/), (7) and (2) seem to be incorrect — supposedly due to errors in marking out the model areas or to wrong technics of sample taking —, the results of simulation calculations are also distorted. With the exception of this one-fifth of the cases, however, the simulation results published agree more than 70% of the time with the values of the mentioned nationally-accepted prognosis.

Beside the ecological district and the quality of the growing site it was mainly as a function of the soil P-status that we attempted to evaluate — as much as the conditions of observation made it possible — the dynamics of phosphorus uptake by winter wheat. In Figure 7 P-uptake by medium-early varieties in fields of different phosphorus status is shown. At the observation points (8/1/) and (18/1/) a reflux type dynamics of the plant P-quantities was separated according to the different phosphorus status of the soil. The amount of April–May rainfall (32.8 mm) measured in the field of the Lower Tisza region (1) was such a low value in comparison to the 105 mm rainfall that the field of the Sopron–Vas Plain received (1), as supposedly set aside the considerable difference in the P-status of the soil. In the actual P-supplying process moreover in the initial development phase of winter wheat, it even reversed the agrochemically expectable result. Besides, the variation of the P-status was determined on the basis of the ammonium lactate soluble P in the upper cultivated layer of soil, and phosphorus infiltration cannot be taken into account. Thus, in the phase of tillering — in the dry–warm B-type year (18/1/) — the low moisture content of the cultivated soil layer may have influenced the rate of P-supply as a decisive factor. The more even development, and the earlier shooting inconsistent with the lower intensity of growth, are explained by the obviously higher ground-water level and consequently

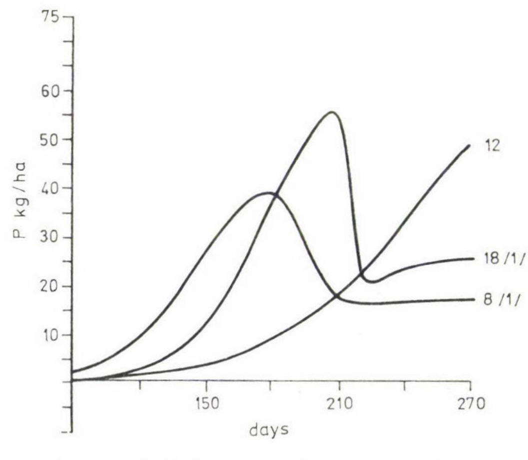

Fig. 7. Curves for the phenodynamical character of aboveground phosphorus accumulation in medium-early winter wheat varieties

more harmonious water regime of the humous alluvium (8/1/), compared to the clay-infiltrated brown forest soil (18/1/). A comparison of curves (1/1/) and (1/3/) shows that in fields with similar nutrient status and identical ecological conditions the phase of intensive P-accumulation of the early variety preceedes that of the medium-early winter wheat. With the same level of P-supply, however, the effect of the agro-ecological district was dominant, and the phosphorus reflux occurred at one site (8/1/) but not at the other (12).

Two early varieties (Novosadska Rana 2 and Száva) were compared for the dynamics of phosphorus uptake at growing sites of the same type (Fig. 8). The influence of the climatic type of year and the effect of the agro-ecological district were also indicated in the course of time of the process, beyond the

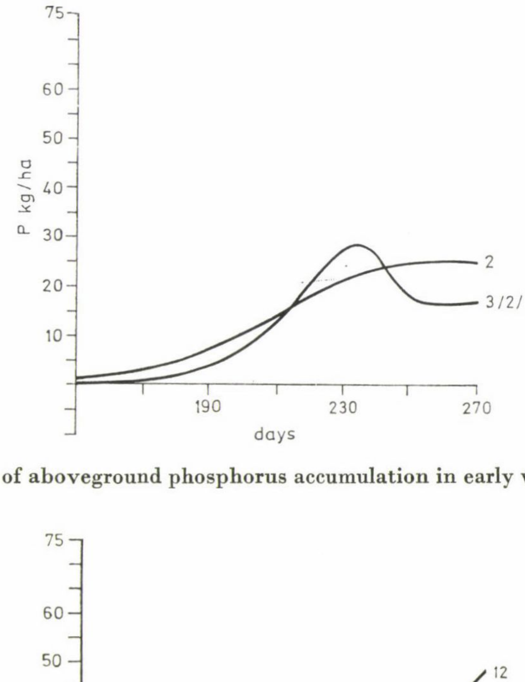

Fig. 8. Time function of aboveground phosphorus accumulation in early winter wheat varieties

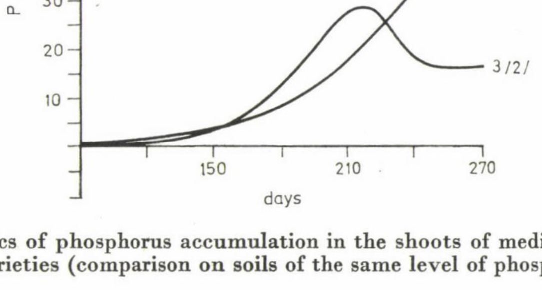

Fig. 9. Phenodynamics of phosphorus accumulation in the shoots of medium-early and early winter wheat varieties (comparison on soils of the same level of phosphorus supply)

quantitative differences of P-uptake. As a function of the climatic type of year of the agro-ecological district, and the maturity group to which the variety in question belongs, the dynamics of phosphorus uptake reflects fun damental differences (Fig. 9). At points (3/2/) with good K-status, the early variety developed with phosphorus reflux, while in district (12) the medium-early winter wheat showed a reflux-free P-accumulation. At the same time, the period of intensivP-u eptake in the variety Száva preceedes — as expected — that in Jubilejnaja 50. The climatic type of year and the variety group with their synergic interaction promoted the accumulation of larger aboveground phosphorus quantity in the (12) wheat stand than in the (3/2/) one.

The dynamics of potassium uptake by wheat varieties was also studied according to growing site, district and nutrient status of soil. The K-uptake of the medium-early Judilejnaja 50 at growing sites of the same category (III) with various levels of supply, in different agro-ecological districts is seen in Fig. 10. In all three cases, characteristic K-reflux but essential differences in the size of maxima and peak time of uptake were noted. The rate of potassium reflux mainly depended on the K-status of the soil.

Similar examinations were carried out at growing sites of category I with medium or above-medium potassium status of soil, in different agro-ecological districts. The potassium uptake of Jubilejnaja 50 altered mainly according to the agro-ecological district (Fig. 11). In winter wheat, besides a characteristic reflux type phenodynamics of K-uptake, reflux-free K-turnover also occurred. All this confirms our observations concerning the reflux dynamics of dry matter formation in the case of potassium uptake as well.

In Figure 12 the process of K-uptake is shown for two early varieties — Száva and Rannaja 12 — in different growing sites and districts. The

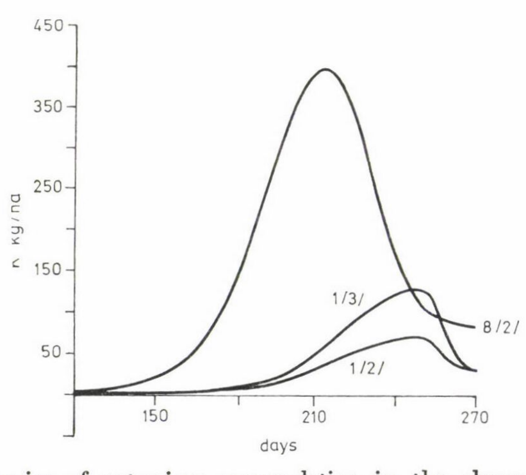

Fig. 10. Phenodynamics of potassium accumulation in the aboveground phytomass of medium-early winter wheat varieties grown at site III with varying levels of potassium supply in soils

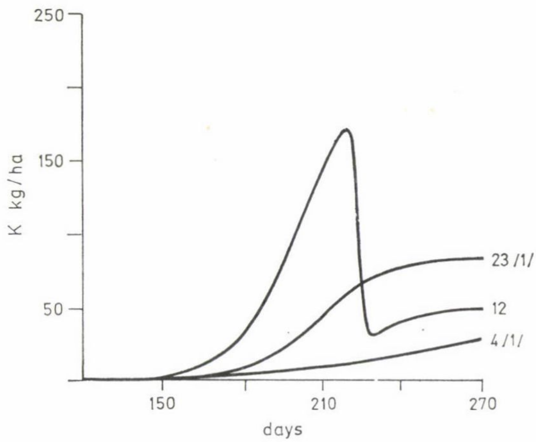

Fig. 11. Phenodynamics of aboveground potassium accumulation in medium-early winter wheat varieties on soils of different potassium status at growing site I

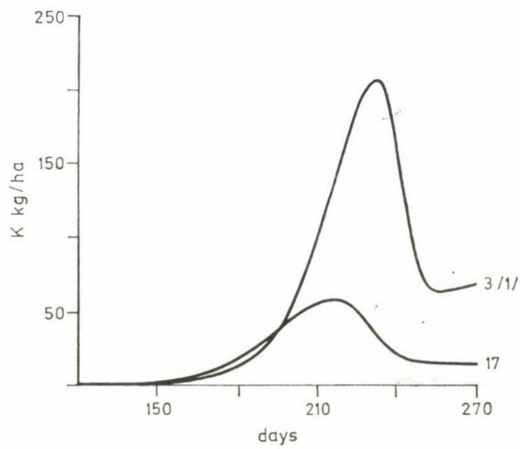

Fig. 12. Aboveground potassium accumulation of early winter wheat varieties grown at sites of the same quality on soils with different levels of potassium supply, as a function of the vegetation period

quantitative difference in the dynamics of K-turnover — of reflux-type in both stand — does not agree with the trend of the difference in the level of supply. The 30 mm amount of precipitation on tillering at the foot of the Alps is less than half of the 69 mm rainfall measured in the field of the Bácska table-land (2), which probably exercised an unfavourable effect on the early potassium-supplying capacity of soil in the district (17). This was a considerable disadvantage, even affecting the subsequent phenophases particularly in the given dry–warm cropyear, compared with the dry–cool climatic conditions of the Bácska fields during the same period.

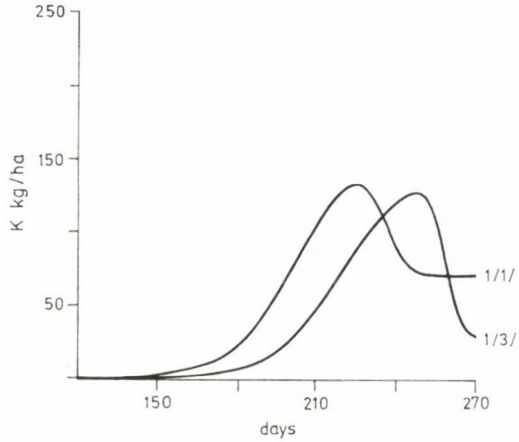

Fig. 13. Comparison of early and medium-early winter wheat varieties for the phenodynamics of potassium accumulation in the same agro-ecological district and growing site

The dynamics of potassium uptake by winter wheat varieties of early and medium-early maturity groups in the case of identical growing site categories III are compared in Fig. 13. The phenodynamics of K-turnover that reaches similar maxima in the two varieties shows differences not only in the times of accumulation peaks and highest K-uptake rates, but also in the rate of K-reflux. The higher K-reflux in Jubilejnaja 50 can be explained by the fact that in the period of reflux, mostly taking place in June, the amount of precipitation in field (1/3/) exceeded 75 mm; while during the reflux of Novosadska Rana 2, that mostly fell to May, the field (1/1/) only received 20 mm rainfall. Thus the probability of the reflux of K^+, an alkali metal ion easily washed out of the foliage that gradually withers while maturing, greatly increased in field (1/3/).

Conclusions

The characteristic phenodynamic differences in dry matter accumulation between early and medium-early winter wheat varieties appear first of all in the earlier acceleration and earlier maximum of dry matter formation in the former.

— The reflux and reflux-free dynamic types of dry matter accumulation can be found in both maturity groups.

— The development of reflux dynamics shows a tendency-like relation with the medium or better-than-medium K-status.

— The farm data and the parameters so far available are sufficient only to give a plausible explanation, rather than exact reasons, for the frequent occurrence of the reflux and reflux-free types of phenodynamics.

— As for its character and quantitative ratio, the (reflux or reflux-free) dynamics of P-uptake displays a parallelism with the dynamics of dry matter accumulation more often than the phenodynamics of K-uptake.

— Linking up the reflux and/or reflux-free character of dry matter formation and nutrient accumulation dynamics with one or another agro-ecological district, or refusing such a generalization, would not be reasonable. However, with a knowledge of the amount of rainfall in the critical periods and of the genetic soil types, it is not likely that reflux is frequent only in certain agro-ecological districts.

— The reflux phenodynamic character linked with an increased level of K-supply demonstrably strengthens in the following order: dry matter formation, P-uptake, potassium accumulation.

— The reflux phenodynamics of potassium quantities accumulated in the aboveground phytomass of winter wheat is a characteristic highly influenced by variety, growing site category and also agro-ecological district the explanation for which lies in the (easily washedout) physiologically active form of potassium, and in the increased importance of rainfall conditions in the post of flowering period.

— On adjusting the K-supplying power of soil to the phenophases of winter wheat the rate of K-reflux must not be neglected.

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Acta Agronomica Hungarica, 37 (1–2), pp. 19–29 (1988)

INTERACTIVE EFFECT OF SOIL WATER CONTENT AND ANTITRANSPIRANT (PMA) ON SOME PHYSIOLOGICAL ACTIVITIES IN MAIZE PLANT

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(Received: 5 June 1986)

The fresh and dry matter, leaf area as well as transpiration rate decreased with the decrease in soil moisture content. Stomatal frequency remained more or less unaffected. After spraying with the antitranspirant phenyl mercuric acetate (PMA), somewhat variable results were obtained. The pigment contents decreased with the decrease in soil moisture content. Moreover, after spraying with PMA, the pigment contents exhibited generally lower values than those of the corresponding unsprayed plants.

The carbohydrate contents exhibited variable values under the various treatments used, but with a general tendency to be lowered after spraying with PMA.

The nitrogen contents were reduced whatever the treatment used.

The lipid contents decreased with the decrease in soil moisture content. This decrease was more obvious after spraying with PMA. The contents of some nutrient elements showed somewhat variable response to drought stress as well as to spraying with the various PMA concentrations.

Keywords: *Zea mays* L., antitranspirant (PMA), soil water content, physiology.

Introduction

The effect of soil water content on plants has been studied to explain the mechanism by which this type of stress induces alterations in plant physiology. Moreover, some trials were made to alleviate the adverse effect of drought by treating the plants with certain chemicals, which are believed to reduce the water loss via the plant leaves. Phenyl mercuric acetate (PMA) was found to be a highly effective substance and its effect was localized with no translocation to untreated parts of the leaf blade (Shimshi 1963a, b; Slatyer and Bierhuizen 1964). To explain the mechanism by which PMA can induce stomatal closure, some hypotheses were made. Mansfield (1967) and Squire and Jones (1971) found that stomatal closure by PMA was always accompanied by reduced CO_2 concentrations within the intercellular spaces, which consequently induce stomatal closure.

The aim of the present work was to test the response of maize plants to soil moisture contents. In addition, an attempt was made to alleviate the effect of drought by spraying these stressed plants with the antitranspirant phenyl mercuric acetate (PMA).

Material and methods

The maize (*Zea mays* L.) plants were grown in pots with clay and sand (2 : 1) and daily irrigated alternatively with water of 0.1 *Hoagland solution* to reach soil moisture levels of 90, 70, 50 or 30% of the full field capacity. The plants were sprayed with an aqueous solution of phenyl mercuric acetate (1×10 M, 1×10^{-4} M or 1×10^{-3} M) were used. Some plants were left unsprayed, to be regarded as a control.

The stomatal frequency of upper and lower epidermis was determined in epidermal strips taken from completely expanded leaves. Fifteen stomatal counts were made successively across each strip using an ocular micrometer. The mean stomatal frequency (number of stomata/mm^2) was calculated.

The transpiration was measured periodically (gm water/dm^2/day or gm/water/plant/day).

At the end of the experimental period, the fresh and dry matter of leaves, stems and roots were determined and water content was calculated.

The leaf area was measured by the disk method (Watson and Watson 1953).

Dry samples of leaves, stems and roots were ground into a fine powder by a micromill and assayed for mineral elements. The versene (disodium dihydrogen ethylenediamine tetra acetic acid) titration method (Schwarzenbach and Biederman 1948) was employed for both Ca and Mg determination. Phosphorus was determined colorimetrically using the method described by Woods and Mellon (1941).

The photosynthetic pigments (chlorophyll-a, chlorophyll-b and carotenoids) were determined using spectrophotometric methods recommended by Metzner et al. (1965).

For the determination of carbohydrate contents the anthrone sulphuric acid method was used (Fales 1951; Schlegel 1965).

The micro-Kjeldahl technique (Peach and Tracey 1965) was employed for the determination of nitrogen contents.

The lipid contents were quantitatively extracted in petroleum ether using the weight method (Meara 1955).

Results and discussion

The stomatal frequency of both lower and upper epidermis of variously treated plants remained more or less unaffected (Table 1). A progressive decrease in the rate of transpiration with the decrease in soil moisture content was recorded. Moreover, spraying with the antitranspirant PMA resulted in an obvious decrease in the rate of transpiration with the rise in PMA concentration (Table 1). This decrease in transpiration with the decrease in soil moisture content accords with the results obtained by other authors (Richards and Eadleigh 1952, Gates 1955, Jarvis and Jarvis 1963, Lahiri 1966, Cox and Boersma 1967, Bieloria and Mendel 1969, Al-Ani 1972, Hsiao 1973).

Since the number of stomata did not show any considerable changes, this decrease in transpiration was mostly due to the closure of stomata. In this respect, Mansfield (1967) and Squire and Jones (1971) reported that this stomatal closure by PMA was accompanied by a reduced CO_2 concentration within the intercellular spaces. Moreover, alternations have also been obtained after the application of PMA to plant leaves (Squire and Jones 1971, Fenton et al. 1976, Malloch and Fenton 1979).

The water content of plants decreased generally with the decrease in soil mositure content. However, after spraying with the antitranspirant PMA these contents exhibited, in most cases, somewhat higher values compared to those of plants subjected only to the corresponding drought stress (Table 1).

Table 1

Water relationship parameters and growth of maize plants subjected to various soil moisture contents and sprayed with various PMA concentrations

PMA concentration	Soil moisture content, %	Stomatal frequency (number of stomata per mm²)		Transpiration (g/dm²/day)	Transpiration water content		Leaf area (dm²/plant)	Fresh weight (g/plant)	Dry weight (g/plant)
		upper epidermis	lower epidermis		g/plant/day	g/g.d. wt.			
0.0	90	89	169	7.06	31.46	8.33	4.47	14.06	1.51
Control	70	88	170	4.15	19.71	8.48	4.76	11.62	1.23
	50	86	169	3.07	9.97	7.46	3.25	7.44	0.88
	30	93	171	0.51	0.53	5.29	1.07	2.63	0.42
1×10^{-5} M	90	84	165	6.45**	28.68**	8.72	4.46	13.21**	1.36**
	70	82	157	4.01	18.96	8.81	4.73	11.34	1.16*
	50	86	164	2.69	9.05	7.96	3.36	7.84	0.88
	30	89	163	0.50	0.53	4.91	1.05	2.27	0.38
1×10^{-4} M	90	77*	168	5.73**	26.00**	8.40	4.54	12.12**	1.29**
	70	74**	158	3.58*	16.03**	9.06	4.50	9.91**	0.99**
	50	82	162	2.01**	7.88	8.35	3.50	6.89	0.75**
	30	83	168	0.42	0.49	5.93	1.15	2.77	0.40
1×10^{-3} M	90	76*	155	4.77**	17.29**	9.15*	3.65**	10.49**	1.03**
	70	78	162	3.42**	15.08**	8.65	4.44	8.98**	0.93**
	50	88	168	3.32	6.51**	7.87	2.82*	6.70*	0.76**
	30	84	173	0.46	0.45	6.67**	0.99	2.53	0.33**
L.S.D. at 5%		1.020	14.83	0.43	2.28	0.75	0.43	0.63	0.06
L.S.D. at 1%		13.75	19.99	0.58	3.08	1.02	0.58	0.85	0.08

* Significant differences in relation to the corresponding reference control.
** Highly significant differences in relation to the corresponding reference control.

The values of leaf area, fresh or dry matter were generally reduced under water stress (Table 1). These suppressing effects of drought are in accordance with the results obtained by other authors using other plants (Boyer 1970, Acevedo et al. 1971, Meyer and Boyer 1972, Hsiao et al. 1976, Rawson et al. 1980, Takami et al. 1981, 1982, Rawson and Turner 1982a, b, Sobrado and Rawson 1984). This reduction in growth could be attributed to the reduction in cell division and/or in cell enlargement (Nicholls and May 1963, Gardner and Nieman 1964, Slatyer 1967, Terry et al. 1971). Stocker (1960) emphasized, in addition that there is a general retardation of some enzymatic activities due to water deficit, particularly, those responsible for photosynthesis. Consequently, a shortage in building materials occurs. The growth of test plants, after being sprayed with the PMA, was variously affected. After treatment with 1×10^{-3} M PMA, the values of the various growth parameters were considerably lower but were still somewhat higher than those of unsprayed plants. Such variable results were also recorded by some other authors. In this respect, Nagarajdh and Ratnasooria (1977) and Imam and Miseha (1978) attributed

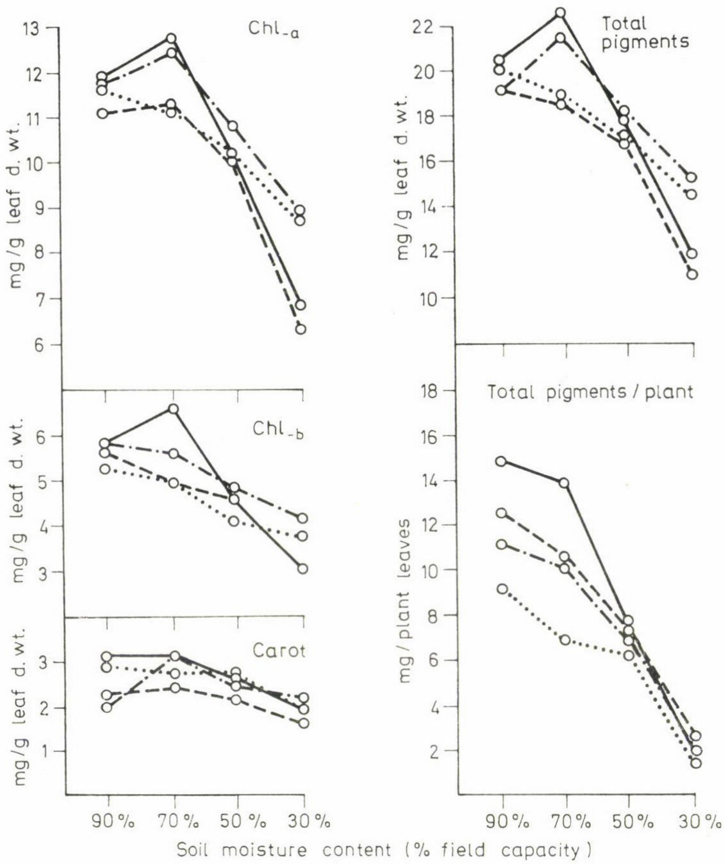

Fig. 1. Interactive effect of some soil moisture contents and some PMA concentrations on pigment contents of maize plants

○——○ unsprayed ○----○ 1×10^{-5} M ○-·-·○ 1×10^{-4} M ○····○ 1×10^{-3} M PMA

the reduction on growth of some of treated plants to the reduction in photosynthesis, which was induced by stomatal closure. On the other hand, the promotion in growth of other plants, especially when treated with low PMA concentrations was attributed mainly to inhibition of respiration (Zelitch 1961 Shimshi 1963, Waggoner 1965, Martin and Lopushinsky 1966, Slatyer 1967, Squire and Jones 1961, Lee et al. 1974, Fenton et al. 1976, Imam and Miseha 1978, and Molloch and Fenton 1979).

The photosynthetic pigments were generally inhibited by water stress (Fig. 1). The plants sprayed with PMA exhibited generally lower values of pigment contents than those of the correspondingly unsprayed plants; and this may lead to a reduction in photosynthesis, which could be magnified by stomatal closure (Nagarajdh and Ratnasooria 1977, Imam and Miseha 1978, Beadle et al. 1981).

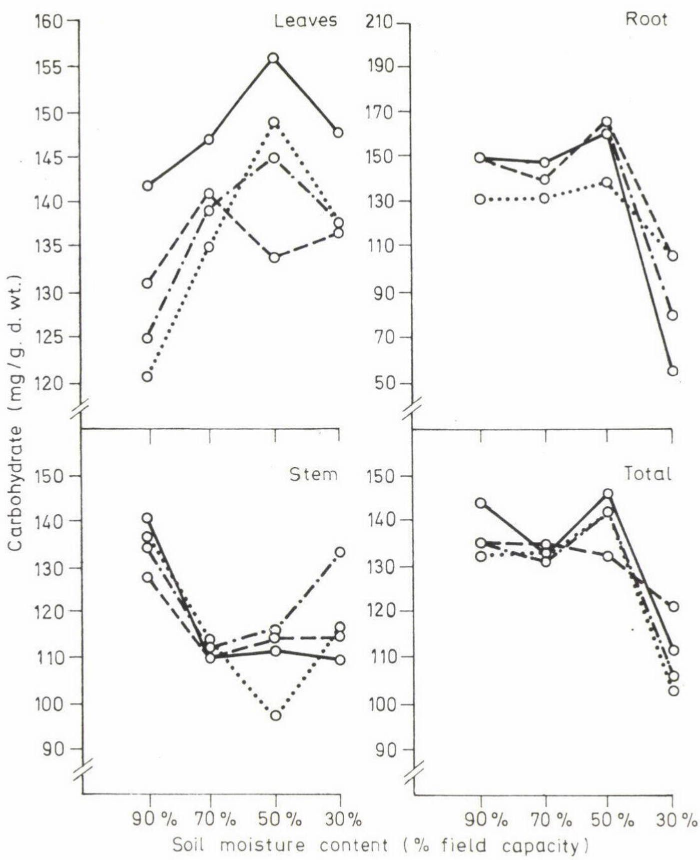

Fig. 2. Interactive effect of soil moisture contents and PMA concentrations on carbohydrate contents of maize plants

o —— o unsprayed o - - - - o 1×10^{-5} M o -·-· o 1×10^{-4} M o ···· o 1×10^{-3} M PMA

A significant reduction in carbohydrate content was recorded after being subjected to water stress (Fig. 2). Similar results were also obtained by other authors using other plants (Eaton and Ergle 1948, Wager 1954, Woodhams and Kozlowski 1954, Saunier et al. 1968, and Lee et al. 1974). This decrease in carbohydrate content may be due to the corresponding decrease in photosynthesis, which could be due to the increase in diffusion resistance of the stomata to CO_2 consequently reducing the amount of CO_2 available for photosynthesis (Uperhurch et al. 1955, Brix 1962, Gale et al. 1966, Adjel-Twum and Splittstoesser 1976). After spraying with low concentrations of PMA, the carbohydrate contents were generally lowered.

The total nitrogen content decreased with the decrease in soil moisture content (Fig. 3). Spraying with PMA generally resulted in a decrease in nitrogen content with the increase of PMA concentrations.

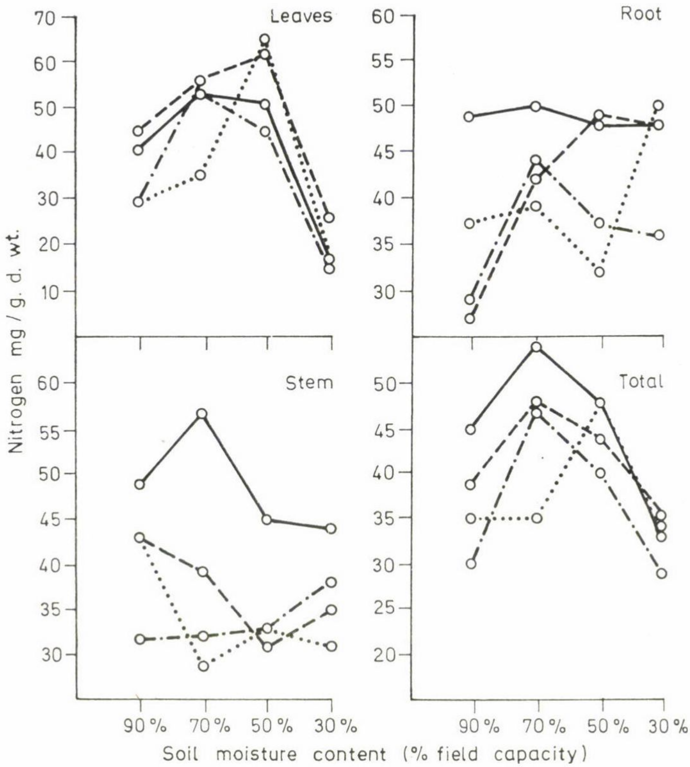

Fig. 3. Interactive effect of soil moisture contents and PMA concentrations on nitrogen contents of maize plants

○——○ unsprayed ○----○ 1×10⁻ M ○-·-·○ 1×10^{-4} M ○····○ 1×10^{-3} M PMA

The lipid content remained more or less unaffected (Fig. 4). After spraying with PMA, the lipid content decreased markedly with the increase in PMA concentrations. Similar results were also obtained by others (Evenvari 1960, Miller and Beard 1967, and Adjel-Twum and Splittstoesser 1976). The accumulation of lipids in plants under drought stress could be regarded as a means of osmoregulation. Such an osmoregulatory effect of lipid accumulation has also been proposed by some researchers who have tested plants subjected to salinity stress (Ahmed et al. 1977, Ahmed et al. 1979a, b, Shaddad 1979)

The calcium contents of leaves and stems remained more or less unaffected, while those of the remainder of the whole plant body decreased with the decrease in soil water content (Table 2). Also after spraying with PMA, the calcium contents of leaves and stems did not show any considerable change; however, in the rest of the whole plant body, the calcium contents decreased with the increase of the antitranspirant PMA concentration.

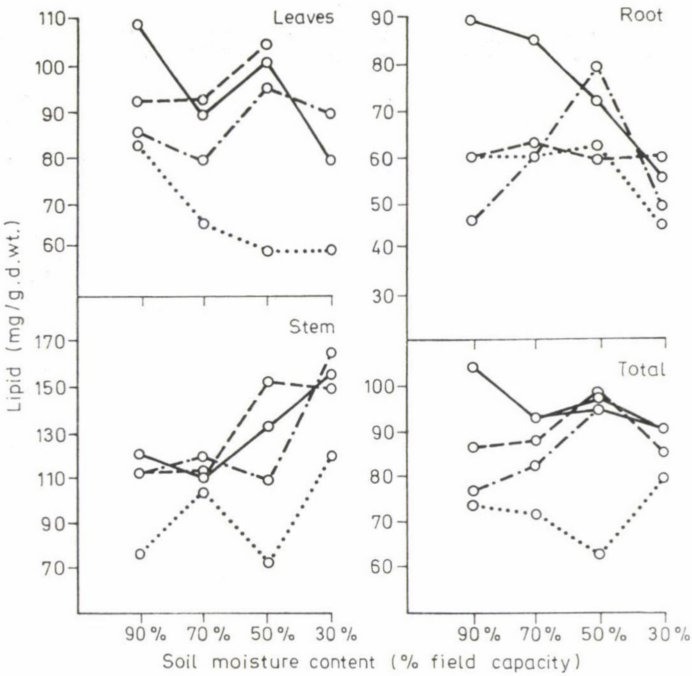

Fig. 4. **Interactive effect of soil moisture contents and PMA concentrations on lipid contents of maize plants**

○——○ unsprayed ○----○ 1×10^{-5} M ○-·-·○ 1×10^{-4} M ○····○ 1×10^{-3} M PMA

The magnesium contents of the plant organs (leaves, stems and roots) as well as of the whole plant body remained more or less unaffected, whatever the soil water content used. When calculated per plant, the magnesium content decrease with the decrease in soil water content. After spraying with PMA these magnesium contents remained, in most cases, more or less unaffected (Table 3).

Phosphorus contents in leaves generally decreased with the decrease in soil water content. In the stems, they remained more or less unaffected, while in roots these contents increased markedly with the decrease in soil water content. The total phosphorus contents, when calculated per g dry weight of mixed plant tissues or per plant, decreased with the decrease in soil water content. After spraying with PMA the contents of phosphorus in different organs were, in most cases, lower than those of the correspondingly unsprayed plants. However, in the roots of plants subjected to 90% or 70% field capacity these contents were relatively higher than those in roots of unsprayed plants. Consequently the total phosphorus contents were markedly lowered in comparison to those of unsprayed plants (Table 4).

Table 2

Calcium contents (mg/g dry weight) of maize plants subjected to various soil moisture contents and sprayed with various PMA concentrations

PMA concentration	Soil moisture content, %	Leaves	Stem	Root	Whole plant	
					mg/g dry wt. plant tissue	mg/plant
0.0 Control	90	13.33	16.67	26.67	18.40	27.75
	70	14.67*	16.00	20.00**	16.51**	20.24**
	50	13.00	15.33	18.00**	14.86**	13.07**
	30	12.67	17.33	16.67**	15.23**	6.39**
1×10^{-5} M	90	12.33	16.00	24.67	16.87**	22.95**
	70	14.17	14.17*	22.67*	16.69	19.30
	50	12.33	15.17	17.33	13.74*	12.04
	30	11.83	17.33	15.33	14.20	5.46
1×10^{-4} M	90	13.33	15.33	21.33**	16.51**	21.29**
	70	12.00**	15.00	18.33	14.46**	14.29**
	50	12.00	12.83**	15.33**	13.02**	9.72**
	30	11.33*	15.33*	14.67	13.70**	5.48
1×10^{-3} M	90	14.00	13.33**	19.33**	15.65**	16.15**
	70	11.67	13.83*	18.33	14.25**	13.57**
	50	12.33	12.00**	15.33*	13.11	9.92**
	30	11.67	14.67**	13.33*	13.34**	4.44*
L.S.D. 5%		1.24	1.67	2.55	1.10	1.75
L.S.D. 1%		1.68	2.26	3.44	1.49	2.37

* Significant differences. ** Highly significant differences.

Table 3

Magnesium contents (mg/g dry weight) of maize plants subjected to various soil moisture contents and sprayed with various PMA concentrations

PMA concentration	Soil moisture content, %	Leaves	Stem	Root	Whole plant	
					mg/g dry wt. plant tissue	mg/plant
0.0 Control	90	5.20	5.20	8.80	6.39	9.63
	70	5.20	4.80	7.20*	5.72	7.02**
	50	4.60	5.20	8.00	5.65	4.97**
	30	4.90	6.00	7.40	6.12	2.57**
1×10^{-5} M	90	6.20	6.40	7.20*	6.54	8.92
	70	6.40	4.30	7.20	6.20	7.17
	50	5.00	5.30	8.40	5.76	5.04
	30	5.70	6.00	8.40	6.77	2.61
1×10^{-4} M	90	5.60	4.60**	8.80	7.10	9.17
	70	4.00	7.35**	9.00*	5.37	5.30
	50	4.00	7.10*	9.20	6.04	4.50
	30	4.80	4.60*	8.00	6.77	2.70
1×10^{-3} M	90	7.10*	8.00**	6.40**	7.14	7.35*
	70	5.00	4.10	6.20	5.72	4.84**
	50	3.80	6.40	8.40	5.71	4.34
	30	3.60	7.20	8.00	6.13	2.12
L.S.D. 5%		1.37	1.55	1.49	1.08	1.10
L.S.D. 1%		1.84	2.09	2.01	1.46	1.49

* Significant differences. ** Highly significant differences.

Table 4

Phosphorus contents (mg/g dry weight) of maize plants subjected to various soil moisture contents and sprayed with various PMA concentrations

PMA concentration	Soil moisture content, %	Leaves	Stem	Root	Whole plant: mg/g dry wt. plant tissue	Whole plant: mg/plant
0.0	90	4.00	1.60	0.72	2.45	3.69
Control	70	3.72**	1.56	0.96	2.23	2.73**
	50	3.00**	1.80	1.51**	2.33	2.06**
	30	1.01**	1.78	1.85**	1.50**	0.63**
1×10^{-5} M	90	2.55**	1.76	0.96	1.84**	2.57**
	70	2.40**	1.73	1.01	1.85*	2.13**
	50	1.92**	1.44**	1.59	1.67**	1.46**
	30	1.25	1.37**	1.60	1.40	0.54
1×10^{-4} M	90	2.86**	1.85**	1.42**	2.01**	2.59**
	70	3.32	1.56	1.17	2.28	2.26**
	50	2.02**	1.66	1.30	1.75**	1.31**
	30	1.44*	1.06**	1.68	1.31	0.54
1×10^{-3} M	90	2.35**	1.54	1.59**	1.92**	1.98**
	70	2.35**	1.47	1.39**	1.85*	1.71**
	50	2.16**	1.37**	1.54	1.79**	1.36**
	30	1.78**	1.18**	1.23**	1.41	0.47
L.S.D. $_{5\%}$		0.39	0.22	0.27	0.31	0.27
L.S.D. $_{1\%}$		0.52	0.30	0.36	0.41	0.36

* Significant differences.
** Highly significant differences.

Generally it can be concluded that the antitranspirant used (PMA) exerted variable effects on the maize plants. The relatively lower concentrations generally had positive effects in alleviating the effect of drought stress; while the relatively higher concentrations had negative effects.

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Acta Agronomica Hungarica, 37 (1–2), pp. 31–35 (1988)

EFFECT OF ZINC ADDITIONS TO ACID SOILS ON THE GROWTH AND TRANSLOCATION OF ZINC, MANGANESE, IRON AND COPPER IN MAIZE

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(Received: 11 July 1985)

In a greenhouse experiment, the effect of Zn additions (0, 125, 250, 500 and 1000 ppm Zn) applied through $Zn(NO_3)_2$ on the growth and translocation of Zn, Mn, Fe and Cu in corn grown on soils differing in composition and properties was studied. The Zn additions decreased the dry matter yield of corn from 2.12 to 0.40 and 3.19 to 1.53 g per pot at both pH 4.4 and 5.4, and it disbalances the translocations of other nutrients in plants. The plant Zn increased significantly with increased levels of added Zn in all the soils. The plant Mn also significantly raised above the control by Zn additions from 2280 to 3437 ppm in Soil A and 162 to 4280 ppm in Soil B. Liming the Soil A reduced eighteenfold the Mn content in maize. This decrease in Mn content was largely due to the pH effect of the soil. The plant Fe and Cu decreased with Zn additions.

Keywords: Addition and translocation of Zn, decrease of dry matter, accumulation of heavy metals, Zn stress, disbalances of nutrients is the soil.

Introduction

Toxicity of Zn has been observed in some agricultural crops and soils around the Zn smelting plants (Singh—Lag 1976). Now that Zn fertilization has become a common agricultural practice its continuous application year after year may result in the excess amount of Zn in soils. Secondly, in the agricultural soils which are used as disposal for industrial wastes, there is every likelihood of the accumulation of the excess heavy metals in soils. In general, the reports of Zn toxicity to plants have involved acid soils. Also, the heavy doses of Zn additions to soils result in the disbalances of other nutrients and thereby affect the biochemical processes. The Zn additions to soils had an antagonistic effect on Mn availability to plants (Singh and Steenberg 1974) in neutral and alkaline soils. However, little information is available about its effects in acid soils where the conditions are quite different from those in alkaline soils. Therefore, the present experiment studies the effect of heavy doses of Zn additions to acid soils on the content of Zn, Mn, Fe and Cu in maize grown on such soils.

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Material and methods

Bulk surface soil samples of the plough layer (0–20 cm) were collected from two locations of RSFSR, USSR for greenhouse study. Soil samples were air-dried, ground and passed through 2 mm sieve. Maize was grown in the greenhouse in plastic pots containing five kg of soil. The levels of Zn were 0, 125, 250, 500 and 1000 ppm Zn as $Zn(NO_3)_2$. A basal application of 428 ppm, N as NH_4NO_3, 200 ppm P_2O_5 and 260 ppm K_2O as KH_2PO_4 and K_2HPO_4 was done. The fertilizers and zinc solutions were manually mixed in the soil. Fifteen seeds of maize were sown in each pots and were thinned to 10 plants after germination. Four replications were provided. Soil moisture was maintained at approximately 60% of the water holding capacity of the soil. The plants were harvested 20 days after germination. The harvested plants were thoroughly washed with double distilled water, dried at 70 °C and weighed. All the results reported are on an oven-dry basis. The samples were ground in a mixer having stainless steel blades. The samples were wet-ashed with $HNO_3-H_2SO_4-HClO_4$ ternary acid mixture (9 : 3 : 1).

The soil samples were also taken from each pot at the time of plant harvest and these were analysed for soil pH (1 : 2.5 soil water suspension) and available Zn by extracting with 1 N ammonium acetate solution pH 4.8, in a 1 : 10 soil solution ratios, shaken for 1 hr. The content of Zn, Mn, Fe and Cu in plant and soil extracts was estimated by Atomic Absorption Spectrophotometry.

The effect of lime application to Soil A was also studied. $CaCO_3$ was added at the rate of 3.5 g/kg soil (named Limed Soil). The levels of N, P, K and Zn additions and the test crop were the same as for other soils.

Results and discussion

The characteristics of the soils used in greenhouse studies are given in Table 1. The soils had pH 4.4 and 5.4 sandy loam in texture, organic carbon 0.6 and 1.2% cation exchange capacity 12.5 and 15.9 me per 100 g soil. The soils differ in Zn and Mn and have almost the same content of Fe and Cu.

Soil pH and available Zn

The additions of $Zn(NO_3)_2$ to soils decreased the soil pH after the crop harvest from 4.40 to 4.10 in Soil A and 5.40 to 5.15 in Soil B. This is attributed to the formation of Zn^{++}, $(ZnOH)^+$ ions with $Zn(NO_3)_2$ additions. The presence of these ions resulted in lowering of soil pH (Bansal and Zyrin 1983). The application of lime to Soil A enhanced the soil pH from 4.4 to 5.7 in control treatment, and $Zn(NO_3)_2$ additions further raised the soil pH to 5.95 (Table 2.)

Table 1

Characteristics of the experimental soils

Soil	Texture	pH	Organic carbon, %	CEC me per 100 g soil	Ammonium acetate pH 4.8 extractable soil cations, ppm			
					Zn	Mn	Fe	Cu
Podzolic Soil A	Sandy loam	4.4	0.6	12.5	4.0	118	8.8	0.4
Podzolic Soil B	Sandy loam	5.4	1.2	15.9	7.2	81	8.0	0.3

Table 2

Effect of zinc fertilization on the dry matter yield and micronutrients content in maize

Zn doses, ppm	Soil available Zn, ppm	Dry matter yield g per pot	Plant micronutrients content, ppm				Soil pH
			Zn	Mn	Fe	Cu	
			Podzolic Soil A				
0	3.5	2.12a*	185a	2280a	100a	9.0	4.40
125	110	1.23b	582b	3550b	115b	9.0	4.35
250	243	1.00c	1490c	3718b	125b	8.7	4.25
500	492	0.55d	3785d	3650b	137c	8.1	4.20
1000	867	0.40d	5040e	3437b	150d	8.1	4.10
			Limed Podzolic Soil A				
0	2.4	2.36a	80a	127a	137a	9.4	5.70
125	37	2.43a	261b	137a	106b	10.6	5.70
250	77	2.51a	660c	199b	100b	10.0	5.75
500	192	2.22a	1714	255c	93b	9.3	5.85
1000	460	1.01b	2213e	301d	90b	9.0	5.95
			Podzolic Soil B				
0	10	3.19a	162a	315a	137a	13.1	5.40
125	120	2.78b	447b	616b	150a	12.5	5.30
250	225	2.71b	886c	734c	148a	10.6	5.20
500	434	2.25c	1911d	779c	131a	10.0	5.20
1000	750	1.53d	4280e	949d	112b	10.0	5.15

* Entries in each subcolumn that have the same letter are not significantly different at the 95 per cent level of confidence.

The soil available Zn estimated after the crop harvest varied from 3.5 to 867 ppm in Soil A, 10 to 750 ppm in Soil B, whereas in limed soil there was twofold decrease in Zn availability and it ranged between 2.4 to 460 ppm. The decrease of soil Zn availability with the addition of lime to acid soil has been reported by Hymes and Swift (1985).

Dry matter yield and micronutrients content

The dry matter yield of maize from Soil A and B decreased significantly with increased levels of added Zn. The decrease was more in Soil A (2.12 to 0.40 g per pot) than in Soil B (3.19 to 1.53 g per pot). In limed soil the yield remained unaffected up to 500 ppm Zn additions, and at 1000 ppm Zn additions there was significant reduction in maize dry matter yield.

The plant Zn increased significantly with increased levels of added Zn in all three soils. In general, the relative content of Zn in maize followed the sequence: Soil A > Soil B > Limed Soil. The plant Zn content in Soil A varied from 185 ppm in control to 5040 ppm at 1000 ppm Zn additions, whereas liming the soil reduced the plant Zn drastically and it was 80 ppm in control to 2213 ppm at 1000 ppm Zn additions. In Soil B, the plant Zn in control was 162 ppm and at highest rate of Zn additions it was 4280 ppm (Table 2). There appeared to be a positive relationship between soil Zn additions and translocations of Zn in plants in these soils having different pH values. A very strong pH effect on the Zn content of the plant was found. Increasing the pH of the soil from 4.4 to 5.7 resulted in a decrease in plant Zn from two to threefold. Lee and Craddock (1969) found a twofold decrease in plant Zn when the pH of and soil was raised to 6.5 with lime additions. In the present investigations, the content of Zn in maize was fairly high and well above the threshold content of Zn toxicity in plants described in the literature (Barker and Chesnin 1975), and resulted in toxicity of Zn in plants.

The effect of Zn on Mn content in maize was of particular interest. The plant Mn was significantly raised above the control by the soil Zn additions in both the soils. There was a strong pH effect on plant Mn. The Mn content in maize grown in Soil A (pH 4.4) varied from 2280 to 3437 ppm, whereas in limed soil (pH 5.7) there was an eighteenfold decrease in plant Mn in control treatment, and an elevenfold decrease at 1000 ppm Zn treatment. Soil with pH of lessthan 5.0 often contain toxic levels of Mn that may be detrimental to optimum growth (Kamprath 1971, Hymes and Swift 1985). The decrease in the uptake of Mn in limed soil may be due to reduced availability of Mn owing to possible precipitation and oxidation at higher pH, and due to its adsorption on $CaCO_3$ surfaces. Bansal and Zyrin (1983) reported increase in plant Mn with Zn additions and a tenfold decrease in plant Mn with liming in oat plants. Whitle et al. (1979) also reported increased leaf Mn content with Zn additions. Excessive plant Mn may affect a plant by reacting with Zn synergetically, antagonistically, or not at all, and there is little information on which to base a judgement. The present study showed the range of reactions to both the excess Zn stress and the Zn induced plant Mn increases. More work on the interaction is necessary to clearly establish the effect of excessive soil Zn per se, as well as such induced effect as the enhanced tissue Mn.

The plant Fe increased from 100 to 150 ppm by Zn additions in Soil A, decreased in Soil B from 137 to 112 ppm and in limed soil from 137 to 90 ppm (Table 2). It appears that in low pH Soil A (4.4), the availability of Fe is greater and Zn additions have no antagonistic effect on the translocation of Fe in the plants. The plant Cu decreased with Zn additions in both the soils. Although the leaf Fe content decreased, it did not approach 50 ppm, a concentration usually considered indicative of simple Fe deficiency (Jones 1972). The decrease in Fe content by Zn excess has been reported by several workers (Takahashi et al. 1979, White et al. 1979). Increasing the amount of Zn in the nutrient solution markedly suppressed iron content in stem. In soybean, Zn interferes with the translocation of iron by inhibiting the reducing capacity of the root (Fe^{+++}, Fe^{++}) or accentuates other reactions detrimental to iron transport. Gilbey (1970) reported reduced plant Cu with Zn additions. The present study suggests that the heavy doses of Zn additions to soils resulted in the disbalances of other micronutrients in plants. Increasing the plant Zn and Mn, and decreasing the Fe and Cu content. The plant Mn in low pH soil (4.4) has much higher content than in other soils. Liming the acid soils reduced drastically the plant Mn.

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Acta Agronomica Hungarica, 37 (1–2), pp. 37–42 (1988)

INFLUENCE OF POTASSIUM FERTILISATION ON THE RESPONSE TO SOIL MOISTURE STRESS IN POTATO

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(Received: 17 April 1986)

Potassium fertilization can improve water use efficiency and thereby maintain K uptake and crop yield. This was investigated with potato as the test crop in a statistically designed field experiment under different intensities of moisture stress, created by applying irrigation at 3 different moisture tensions. Each of these were again tested at 5 different levels of K fertilisation. Irrespective of K levels, tuber yield decreased with increasing moisture stress and increased with increasing K fertilisation, when moisture variations were not taken into consideration. The maximum increase in yield per unit of added K_2O was recorded at the lowest level (60 kg) of K fertilisation in plots irrigated at 0.3 and 0.6 atmospheric tensions, whereas it was observed at 120 kg level of K_2O addition in the driest plot. Irrespective of stages of crop growth, a significant increase in K uptake was noted with an increase in K fertilisation, and significantly decreased with decreasing soil moisture levels. That the reduction in K-availability in less frequently irrigated fields could be largely compensated by raising the level of K fertilisation, was clearly demonstrated.

Keywords: Soil moisture stress, K-availability, K-nutrition and yield of potato.

Introduction

The soil moisture content affects the rate of transport of potassium in the soil system and hence its availability to plants. The role of potassium in water uptake in green house and field studies of yield response to potassium in different degrees of moisture stress situations, has been emphasized by many workers (Saxena 1985). Mengel and Kirkby (1980) reported a decrease in the osmotic potential of root cells when the K uptake was high, resulting in an increase in water uptake. Maize roots penetrated 60 cm deeper in K, fertilised over the corresponding unfertilised soil of Illinois, giving access to an extra 10 cm water (Edwards 1981). A unique specific role of the K^+ ion in stomatal regulation in most plant species has also been reported by Fischer and Hsiao (1968). Water stress causes a sharp increase in the concentration of abscisic acid in leaves (Hsiao 1973) and plants well supplied with K are associated with a lower level of abscisic acid. Thus, it is indicated that the response to potassium in limiting the soil moisture level may improve water use efficiency

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and thereby maintain crop yield. However, very few studies on this aspect have been conducted on crops growing on a soil not deficient in potassium. Hence, whether the response to K fertiliser under a drier state is actually due to the effects on the soil K-availability, or to the improvement of drought tolerance by the plant, is not clearly interpreted. Although this paper does not claim to treat this aspect comprehensively, it is an attempt to increase our knowledge towards this objective. The effect of varying intensities of drying, alternated with wetting of soil through irrigation at different soil K levels, in relation to K-nutrition and the yield of potato as a test crop, was studied in the present investigation.

Material and methods

The field experiment was laid out in a split plot design with 3 irrigation levels in the main plot and 5 K levels in the subplot. All the treatment combinations were replicated 3 times. The gross plot size of the treatment was 2.5×4 m. The 3 moisture treatments consisting of irrigation based on a tensiometer reading, corresponding to 0.3 (M_1), 0.6 (M_2) and 0.9 (M_3) atmospheric tension. The 5 treatments representing K levels corresponded to 0 (K_1), 60 (K_2), 120 (K_3), 180 (K_4) and 240 (K_5) kg K_2O/ha applied as muriate of potash. The experimental field soil samples were clay loam in texture and had pH 7.25; organic C 0.54%, CEC 13.74 m.e/100 g; total N 0.06%, WHC 56.87%, water soluble K 20 ppm exchangeable K 375 ppm and non-exchangeable K 1020 ppm.

The potatoes (var. Kufri Jyoti) were sown at 50 cm row to row, and 10 cm seed to seed spacing. A basal dose of N and P was applied a 100 kg N/ha and 150 kg P_2O_5/ha respectively. Nitrogen a 100 kg/N/ha was top dressed after 40 days of sowing. A full dose of K was applied as basal application. Irrigation was applied as per treatment, indicated by a tensiometer inserted in each plot. Adequate plant protection measures were taken. Immediately after harvest, the tuber yield/plot was recorded. The K content in the above-ground plant samples and tubers was analysed on the 40th day after sowing and after the crop harvest. The K content in different extracts was estimated photometrically, using a "Systronix" type 121 Flame Photometer. The data on yield and K concentration of the plant samples were evaluated by analysis of variance. The standard error of mean as well as critical differences was calculated at a 5% level of probability, to test the significance of mean for the treatment differences.

Results and discussion

Results in Table 1 reveal that regardless of K levels, tuber yields decreased with an increasing moisture stress ($M_1 > M_2 > M_3$); and irrespective of the moisture levels, tuber yields increased with an increasing level of K fertilisation. The statistical analysis, however, failed to find any significant difference in tuber yields between M_1 and M_2 moisture levels but significant yield variations were noted at each of the five levels of K addition. As the desired soil temperature does not exist throughout the potato growing season (November to February), greater response of crop yield of potato to more frequent irrigations may partly be attributed to the adverse effect of frost on the crop, when irrigated at longer intervals. That the manipulation of soil moisture through irrigation to a large extent can influence the thermal regime

Table 1

Effect of different moisture levels on yield of potato tubers (t/ha) at different levels of K fertilization
(Mean of three replicates)

Levels of K kg K_2O/ha	Irrigation applied at tensions (atmosphere) 0.3	0.6	0.9	Mean
0	22.851	21.622	18.396	20.936
60	26.575	24.089	18.435	23.033
120	26.062	24.441	24.133	24.865
180	28.516	25.793	24.195	26.168
240	29.981	28.876	24.304	27.720
Mean	26.797	24.964	21.881	

SE_m for main plot = 6.94 (irrigation) CD 5% = 2.726

SE_m for sub plot = 10.89 (K levels) CD 5% = 3.181

of soil, has also been reported by Box et al. (1963). Apparently each moisture regime brings about a change in the thermal regime of the soil, and how closely it approaches the optimum soil moisture depends upon the prevailing weather conditions. In the light of the above discussion, the results of this study suggest that careful planning of irrigation has a considerable scope for improving the yield of potato in this region.

The percentage yield increase of potato tubers per kg of K_2O, added at each of the three different moisture levels with increasing K fertilisation, was computed and the results are presented in Table 2. When irrigations were applied at 0.3, 0.6 and 0.9 atmospheric tensions, the maximum percentage increase in yield per kg of added K_2O was 62.06, 41.11 and 48.31, respectively (Table 2). Of these, the first two values corresponding to 0.3 and 0.6 atmospheric tension were observed at 60 kg level of added K_2O; whereas, the third one, i.e. 48.31% increase in yield of potato per kg of added K_2O, was recorded

Table 2

Effect of different moisture levels and increasing K fertilization on the percentage increase in yield of potato per kg of K_2O added

Levels of K kg K_2O/ha	Irrigation applied at tensions (atmospheric) 0.3	0.6	0.9
60	*62.06*	*41.11*	1.65
120	26.75	23.49	*48.31*
180	31.47	23.17	32.55
240	29.70	30.22	24.86

at 120 kg level of K fertilisation in plots irrigated at 0.9 atmospheric tension. The marked rise in the yield of potato tubers with the increase in levels of irrigation was reported by Ingle and Dohatonde (1975). More recently Reddy and Shastry (1983) also reported higher tuber yield in fields irrigated at the IW/CPE ratio of 1.05 and a drastic fall in production with irrigation at the IW/CPE ratio of 0.60.

The total K uptake up to the 40th day stage of growth of the potato crop in each of the five levels of K fertilisation, and three levels of moisture treatments, are presented in Table 3 and at harvest in Table 4. The results indicate that irrespective of the stage of growth, a significant increase in K uptake occurred with the increase in K fertilization and decreased significantly with the decreasing level of soil moisture. The result thus indicates the vital role of soil moisture in the uptake of potassium by potato crop.

The results (Tables 3 and 4) further bring out an important point. The reduction of K availability in less frequently irrigated fields could be compensated by raising the level of K fertilisation. A perusal of the data (Table 3) makes it clear that at the 40th day stage of growth, K uptake by the potato crop fertilised with K a 60 kg K_2O/ha was 67 kg/ha, when grown with irrigation at 0.3 atmospheric tension. But when irrigation was applied to the field at 0.6 atmospheric tension, an almost similar uptake of K (68 kg/ha) was observed at 120 kg level of K_2O addition. Similarly, K uptake of 54 kg/ha was observed in the plots receiving no K fertilisation (K_0), irrigated at 0.6 atmospheric tension; and an almost similar uptake (58 kg/ha) was noted at 60 kg K_2O/ha level of K addition, when irrigated at a much drier condition (0.9 atmospheric tension). These phenomena were more clearly observed in

Table 3

Effect of different moisture levels on total K uptake (kg/ha) by potato crops (tuber + plant herbage) at different levels of K addition at 40th day stage of growth

(Mean of three replicates)

Levels of K kg K_2O/ha	Irrigation applied at tensions (atmosphere)			Mean
	0.3	0.6	0.9	
0	52	54	45	50
60	67	64	58	63
120	76	68	60	68
180	86	75	72	77
240	93	90	82	88
Mean	75	70	63	

SE_m for main plot = 0.006 (irrigation) C.D. 5% = 0.2 SE_m for sub plot = 0.0139 (K levels) C.D. 5% = 0.4

Table 4

Effect of different moisture levels on total K uptake (kg/ha) by potato crop (tuber + plant herbage) at different levels of K addition at harvest

(Mean of three replicates)

Levels of K kg K_2O/ha	Irrigation applied at tensions (atmosphere) 0.3	0.6	0.9	Mean
0	49.3	48.5	40.9	46.2
60	50.1	48.8	42.4	47.1
120	50.7	49.3	46.1	48.7
180	51.6	52.8	48.8	51.0
240	52.7	54.3	52.1	53.0
Mean	50.8	50.7	46.0	

SE_m for main plot = 0.013 (irrigation) C.D. 5% = 0.5

SE_m for sub plot = 0.009 (K levels) C.D. 5% = 0.3

the results obtained at the harvest stage (Table 4). The amount of K uptake (493 kg/ha) noted at 0 level of K fertilisation in the field receiving irrigation at 0.3 atmospheric tension was found to be the same in the field treated with 120 kg K_2O/ha, but receiving irrigation at 0.6 atmospheric tension. Similarly, the K uptake by the crop at 60 kg/ha level of K fertilisation in the plots receiving irrigation at 0.6 atmospheric tension (488 kg/ha) was exactly the same as was observed in the plots irrigated at 0.9 atmospheric tension, but treated with a higher level (180 kg K_2O/ha) of potassium.

The results of the present study corroborate the findings in the experiments conducted by Grimme (1976), in which the roots of the test plant were divided between two media. In one media, half of the root systems was supplied with all the nutrients except K with a constant water source; the other medium was soil in which the moisture and available K contents were varied. The results indicated that K uptake by maize was greatly reduced by lowering the soil moisture content, but they also showed that the reduction could be partly offset by raising the quantity of available K in the soil. The higher levels of moisture are likely to have enhanced the dynamics of soil K by dilution (Singh and Sekhon 1977), accelerated diffusion of K (Nye 1972) and reduced K fixation (Ueddy and Shastry 1983).

Acknowledgements

The authors are grateful to the Potash Research Institute of India for providing financial assistance to the first author.

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Acta Agronomica Hungarica, 37 (1–2), pp. 43–46 (1988)

INFLUENCE OF FOLIAR AND SOIL-APPLIED TITANIUM ON TOMATO

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(Received: 30 May 1986)

A greenhouse experiment was carried out with tomatoes to evaluate the effect of foliar and soil-applied Ti at 0.25, 0.5, 1 and 2 ppm levels of watersoluble Ti. Foliar spray was found to be the best method of applying Ti, as it significantly enhanced the dry matter production of tomatoes and the uptake of Mg, Ti, Al and V over control, while soil-applied Ti had no effect.

Keywords: Titanium, foliar and soil-application, tomato, uptake.

Introduction

In soil, the total content of Ti is fairly high but its strong bonding with silicate minerals and the insolubility of its oxides leads to extremely low amounts of soluble or available Ti (Pais et al. 1979). In the recent literature, Ti has been reported to play an important role in the nutrition of crop plants (Pais et al. 1977, Nand Ram et al. 1983, Fehér et al. 1984). Therefore, the present study was undertaken with tomato *(Lycopersicum esculentum)* to compare two methods of Ti application, namely, foliar spray and soil-application.

Material and methods

The greenhouse experiment was conducted in a Belgian sandy soil-Oostakker (Udipsamment) having the pH 6.8 and containing 0.22, 1.72 and 72 ppm water soluble, NH_4OAc-EDTA and aque-regia extractable Ti, respectively. Two methods of Ti application (viz.: foliar spray and soil-application) were compared at 0.25, 0.5, 1 and 2 ppm levels of water-soluble Ti applied through dicyclopentadienyl titanium chloride ($C_{10}H_{10}Cl_2Ti$) triplicated in a completely randomized design. One kg of soil in each pot was incubated with a nutrient solution consisting of 0.25 g each of NH_4NO_3, $CaH_2PO_4 \cdot 2\,H_2O$, K_2SO_4 and $MgSO_4$ for a fortnight at field capacity moisture. For soil-application, Ti was mixed into the soil as per treatments along with the nutrient solution. Eight tomato seeds were sown in each pot and thinned to five uniform plants after emergence. The pots of the treatments of foliar spray were sprayed with Ti solutions at 30 and 45 days after sowing. Plants were harvested 60 days after sowing, washed with distilled water and, after oven-drying at 60 °C to constant weight, the dry matter yield was recorded. Following dry ashing at 450 °C, the chemical analysis of plant samples for Mg by atomic absorption and trace elements: Ti, Cu, Zn, Mn, Fe, Al and V, by an Inductively Coupled Plasma Spectrophotometer (Cottenie et al. 1982), was carried out.

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Results and discussion

The data pertaining to the dry matter yield of tomato plants presented in Table 1 reveal that foliar spray of Ti significantly enhanced the dry matter production and produced a response of 0.442 g/pot over control. Moreover, the

Table 1

Effect of different methods of Ti application on the dry matter yield of tomato (g/pot)

Methods of Ti application	Level of water soluble Ti (ppm)				Mean
	0.25	0.50	1.00	2.00	
Soil-application	1.504	1.604	1.749	1.704	1.638
Foliar spray	1.797	1.973	2.048	1.873	1.923
Mean	1.650	1.788	1.898	1.788	
Control	1.481				
C.D.$_{5\%}$					

(i) Control vs. treatments 0.312
(ii) Methods of Ti application 0.208

highest production of dry matter, 2.048 g/pot, was noted at 1 ppm level of water-soluble Ti applied through foliar spray. On the other hand, when Ti was applied into the soil, the dry matter yield of tomato was statistically at par with that of control. It is likely that soil-applied Ti may be rendered unavailable by fixation and precipitation in the form of TiO_2.

Foliar-sprayed Ti markedly enhanced the uptake of Mg, Ti, Al and V by tomato plants, while it did not much influence the uptake of other elements under study (Fig. 1). Soil-applied Ti did not show any effect on the uptake, which was markedly improved with the increase in the levels of water-soluble Ti applied through foliar spray. As compared to control, additional uptake of 1.58 μg/pot of Ti was recorded due to the foliar spray of Ti.

From these results, it is concluded that the response of tomato to foliar-sprayed Ti may be ascribed to the Ti-promoted photosynthetic activity (Nand Ram et al. 1983) and Ti, being a transitional element, it presumably influenced the oxidation-reduction processes and enzymatic activity within the plant (Dobrolyubsky 1961, Vlasyuk et al. 1967) only low concentrations of Ti have to be applied to avoid precipitation of TiO_2 because only the soluble forms of Ti are easily absorbed by the leaves (Pais et al. 1977). Foliar spray up to 1 ppm water soluble Ti was beneficial for tomato and it was in accordance with Hara et al. (1976), where the addition of more than 1 ppm has been reported to be phytotoxic. Higher photosynthetic activity leading to higher nutrient demand resulted in the enhanced uptake of elements, as a consequence of foliar-applied Ti.

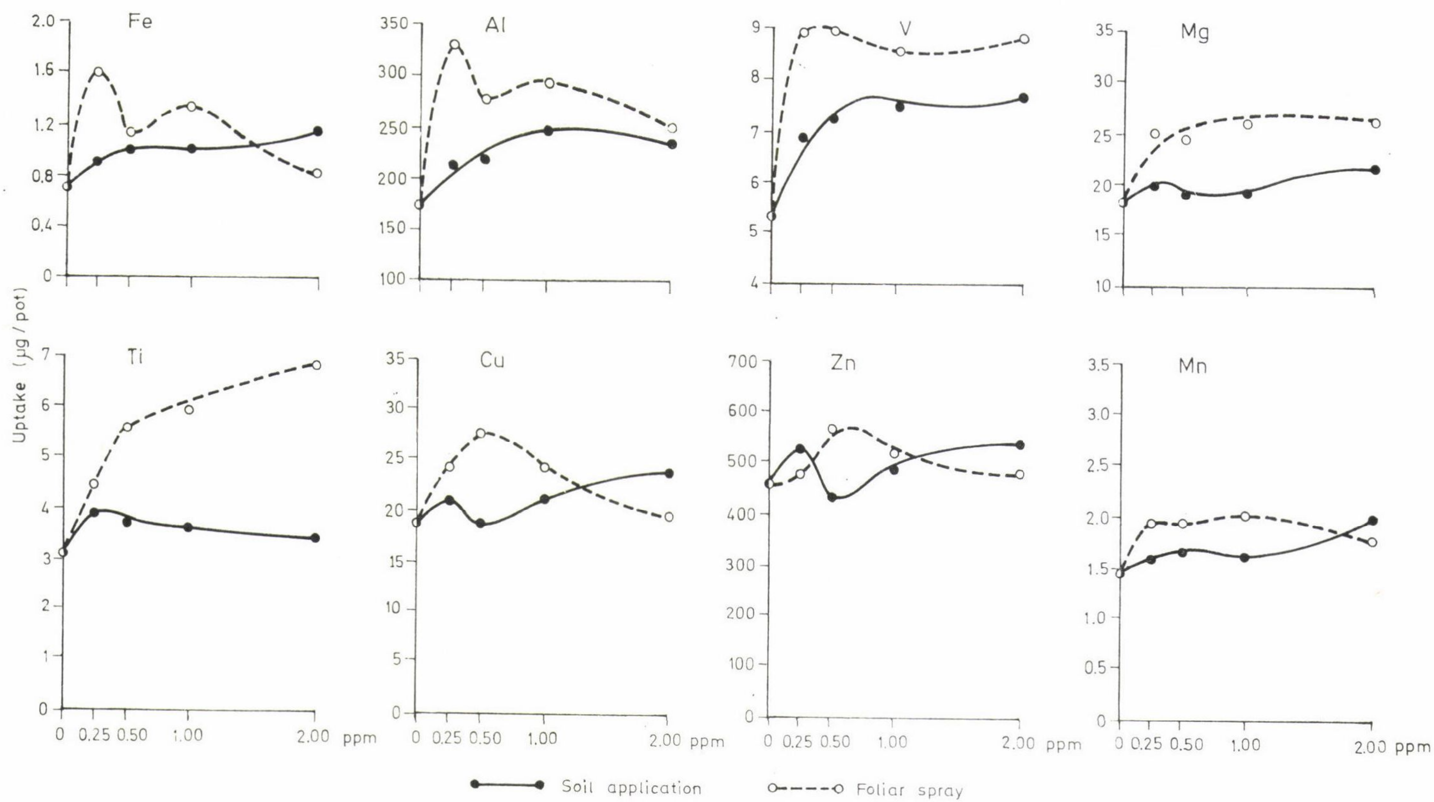

Fig. 1. **Effect of Ti application on the uptake of Mg and trace elements by tomato**

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Acta Agronomica Hungarica, 37 (1–2), pp. 47–54 (1988)

THE INFLUENCE OF HERBICIDAL APPLICATIONS ON SEED QUALITY OF WINTER WHEAT

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(Received: 4 January 1985)

Seed samples from three cultivars of winter wheat were treated with half, normal, double, fourfold and eightfold doses of eight herbicides and tested to study the effect of these treatments on seed quality. The results indicated that different doses of herbicide applications had significant effects on germination and vigour tests. It was found that the herbicides Banvel 2,4-D, Tribunil and Arenol increased both germination and vigour percentage. Generally, the increase in dead seeds, abnormalities and non-vigours seedlings after aging was mainly due to protein denaturation. Also the data showed stimulations in germination and vigour increments due to doses of about normal or twofold the minimum inhibitory dose of all the herbicides used. In addition, the different cultivars of winter wheat exhibited varying degrees of sensitivity to the herbicide treatments applied initially for weed control.

Keywords: Winter wheat, reed quality, herbicides.

Introduction

Weed control must be obtained with herbicides, since cultivation is not possible in no-tillage crops. Chemicals can solve many problems but they also create new ones. The new problems are solved by the use of herbicide rotations or by mixtures, in order to broaden the spectrum of weeds that can be controlled. Nowadays it is possible to control weeds effectively without risk to the crop, prvided that the right product is applied at the right time (Audus 1976). However, the benefits of this positive effect can be reduced or even offset completely by phytotoxic products. The use of herbicides leads to bigger yields, whereby the improvement increases with the degree of infestation. In general, the influence of herbicides on crop yield varied between a reduction of 13% and an increase of 19% (Zemánek 1980). For example, Kees (1968), Mydlilova and Zemánek (1976) and Kapeluszny (1979) found that herbicide treatment increased the grain yield in winter wheat.

In recent years the role of herbicides in seed quality has been the subject of a considerable amount of research. Lorenzoni (1962) first reported that very dilute concentrations of simazine would stimulate seed germination and the growth of seedlings. An indirect effect of subtoxic levels of herbicides was

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discovered by Schweizer and Ries (1969), hence wheat seed that contained more protein as the results of chemical applications or nitrogen, increased the rate of germination and developed into larger seedlings. The improved vigour of the seedlings was shown to be related to an increase in the protein in the endosperm of wheat (Low and Ries 1973). This increased protein content was also demonstrated to be rich in the amino acids proline and glutamic acid (Low et al. 1972).

The individual varieties of winter wheat show varying degrees of sensitivity to the products used for weed control. These differences in sensitivity become more readily apparent when the herbicide is applied at overdosage rates. For this reason trials were conducted at twice and in some cases even more than twice the recommended application rate parallel to trials at the normal rate (Gournay et al. 1973).

Since there is little information available on the effect of herbicides on the seed quality of wheat in the second generation, the present study was undertaken to evaluate the effect of different doses of herbicides applied in the spring on the quality of the winter wheat seed produced.

Material and methods

Field experiments were set up during the growing seasons of 1981 and 1982 at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár. The materials used in this investigation included three winter wheat cultivars, Mv4, Mv8 and Mv9. The plants were treated with five doses, namely half, normal, double, fourfold and eightfold the normal dose for each herbicide, as follows:

Herbicide	Normal dose	Active agent
1. Arelon 70 Wp	2.0 kg/ha	75% isoproturon (N-(4-izzopil-phenyl)N'N-dimethyl carbamide)
2. Faneron multi 50 Wp	2.0 l/ha	30% bromofenoxim + 12% tebuthylazine /(dibromo-4-hydroxy-benzaldehyde-0-) (2,4-dinitro-phenyl)-oxim/
3. 2,4-D	2.0 kg/ha	Dikamin D (40% 2,4-D = 2,4-dichloro-phenoxy-acetic acid)
4. Aniten D	2.5 l/ha	30% 2,4-D + 8% flurenol (9-hydroxy-fluorene) /9/-carbonic acid
5. Dicuran 80 Wp	2.0 kg/ha	80% Chlorotoburon /N-(3-Chloro-methyl-phenyl). N'N'-dimethyl-carbamide/
6. Dikotex	3.5 l/ha	23% MCPA (2-methyl-4-chloro-phenoxy-aceric acid)
7. Tribunil Combi	4.0 l/ha	35% methabenzthiozuron + 40% dichloroprop (N-methyl-N-/2-benzthiazobyl/N-N methyl-carbamide) (2-/2,24-dicloro-phenoxy/-propionic acid)1
8. Banvel M	3.0 l/ha	40% MCPA + 3% dicamba (2-methoxy-3,6-dichloro-benzoic acid salt)

These application treatments were applied in the spring when the plant had 3–6 leaves, as post-emergence herbicides. In general, all the agricultural processes and the agronomic measurements were carried out according to those usually used under local experimental conditions.

Samples from the seeds produced in all the treatments were taken to study the effect of herbicide applications on wheat seed quality. These experiments were established as a randomized complete block design with four replications, at the Institute for Plant Production and Qualification, Budapest, in the second half of 1982 and the first half of 1983 for the seasons 1981 and 1982, respectively. After cleaning, the seeds were graded (greater than 2.2 mesh). The tests carried out in the laboratory to determine seed characteristics were as follows:

Standard germination test

4×50 seeds of each treatment were germinated in one row on 17×50 cm rolled paper towels at 20 °C. The final counting and evaluation of the seedlings were made 7 days after planting. Then the percentage germination, abnormal seedlings and dead seeds were recorded according to ISTA rules (1976).

Vigour test

4×50 seeds of each treatment were germinated in one row on 17×50 cm wetted paper. The rolled papers were put into plastic bags and incubated at 10 °C for 12 days in the dark. The seedlings were classified as vigorous or non-vigorous. The vigour percentage was calculated from seedlings which had a coleoptile at least 4 cm long and a strong root system. Abnormal seedlings and dead seeds were also recorded according to ISTA rules.

Accelerated aging test

This test involved the exposure of small samples of seeds from all treatments to very adverse conditions for a specific period. Thus, the seeds were exposed to a temperature of 45 °C and 100% R.H. for 48 hours in a chamber in which the desired environmental conditions were maintained. Germination and vigour tests on aged seeds were evaluated as described above.

Statistical analysis

All the data of two seasons were collected and computed in one analysis of variance with three factors, because there were negligible differences between the results of the two years. Differences between treatment means were tested with an L.S.D. test at the 5% level of probability for the characters measured.

Results

The analyses of variance for the characters tested are shown in Tables 1 and 2. It is evident that the effect of herbidice, dose, cultivar and their interactions on germination and seed vigour before and after aging were significant at different levels of probability. In a few exceptional cases they were unsignificant. This means that the seed characteristics of winter wheat cultivars were highly affected by treatment with different herbicides and doses and that the differences between character means in relation to most treatment were real and significant. However, the cultivar mean square had the largest magnitude for all characters except in the case of non-vigorous seedlings after aging. The germination percentage of the herbicide treatments had a

Table 1

Mean squares of herbicides (A), doses (B), cultivars (C) and their interactions for seed germination characteristics of winter wheat, before and after aging

S.O.V.	d.f.	Before aging			After aging		
		Germination	Abnormal	Dead	Germination	Abnormal	Dead
		%					
Herbicides (A)	7	23.04***	4.80*	19.65***	10.27	8.59**	2.63
Doses (B)	4	80.29***	7.76**	76.93***	25.39**	16.25***	11.39*
A×B	28	13.54***	2.58	10.93***	19.65**	8.96***	6.30**
Cultivar (C)	2	197.34***	8.07*	139.84***	87.55***	83.33***	38.56***
A×C	14	11.96**	2.84	5.07+	10.98*	9.48***	7.12*
B×C	8	76.71***	3.68+	51.39***	9.67	4.81	21.90***
A×B×C	56	11.62***	3.43**	9.48***	9.31*	4.61*	5.33*
Error	357	4.63	1.93	3.08	6.04	3.00	3.53

+, *, **, *** Significant at 10%, 5%, 1% and 0.1% levels of probability, respectively.

strong effect on the response to different doses, as indicated by the highly significant herbicide × dose interaction. Although germination and vigour were similar in significant mean squares, the responses of vigour to herbicide and the dose × cultivar interaction were different than those of germination. It is obvious (Table 2) that the mean squares for non-vigorous seedlings were attributable to differences in vigour.

The data in Table 3 reveal significant differences between the herbicide treatments with respect to germination and vigour. Nevertheless, there were no significant differences between herbicide means in relation to germination percentage after aging. The exception was tribunil, which differed insignificantly from arelon and gave a significantly higher germination percentage that the other herbicides used. In general, the percentages of both germination and vigour decreased where the number of dead seeds and abnormal seedlings increased after aging.

However, vigour is considered as a good indication of field emergence and seedling growth. Therefore, most herbicides can be ranked depending on the decrease in vigour; thus tribunil, benvel, arelon, dikotex and 2,4-D were the most effective for better seed characteristics in winter wheat before aging. On the other hand, the order was feneron, benvel, arelon, dicuran and tribunil after aging.

With respect to varying doses, the germination and vigour were significantly different in each case, regardless of the herbicide treatment used (Table 4). The results indicated that increased herbicide concentrations reduced the germination percentage and improved the vigour percentage in doses higher

Table 2

Mean squares of herbicides (A), doses (B), cultivars (C) and their interactions for seed vigour characteristics of winter wheat before and after aging

S.O.V.	d.f.	Before aging				After aging			
		Vigorous	Not vigorous	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead
Herbicides (A)	7	335.22***	221.98***	15.35*	4.08	791.92***	861.58***	70.22***	4.34
Doses (B)	4	967.37***	860.59***	31.19***	10.90+	2907.59***	2815.48***	36.42*	7.16
A×B	28	396.29***	318.74***	12.27**	4.73	3632.56***	3179.56***	33.50***	8.78
Cultivars (C)	2	6774.76***	6351.97***	128.66***	41.76	5477.90***	2656.72***	1207.86***	38.16**
A×C	14	275.76***	240.65***	6.06	7.71+	4185.37***	3989.76***	34.93**	7.28
B×C	8	412.50***	382.56***	6.47	2.22	2091.94***	2176.55***	14.63	22.35**
A×B×C	56	278.49***	272.04***	8.51*	6.32+	1992.99***	1847.76***	18.18+	8.60
Error	357	44.63	31.96	5.86	4.93	46.56	45.42	13.88	6.87

+, *, **, *** Significant at 10%, 5%, 1% and 0.1% levels of probability respectively

Table 3

Means for the effect of different herbicides on seed germination and vigour characteristics before and after aging in winter wheat cultivars

Herbicide	Before aging							After aging							Overall mean	
	Germination	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead	Germination	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead	Germination	Vigorous
	%															
Arelon	95.1	2.0	2.7	81.3	13.0	3.2	2.4	93.4	2.9	3.7	61.6	27.0	8.1	3.3	94.3	71.5
Faneron	94.6	1.7	3.7	80.0	14.2	3.5	2.3	93.2	3.0	3.8	63.1	26.5	6.4	3.1	93.9	71.5
2,4-D	95.4	1.7	2.9	80.3	14.9	2.8	2.0	92.8	3.4	3.7	58.0	31.5	7.6	2.7	94.1	69.1
Aniten	93.8	1.8	4.4	75.1	17.9	3.8	2.9	93.0	3.4	3.6	53.1	36.3	7.6	3.0	93.4	64.1
Dicuran	94.8	1.7	3.5	77.9	15.3	3.7	2.6	93.0	3.7	3.3	61.3	25.6	9.5	3.5	93.9	69.6
Dikotex	94.3	2.5	3.3	81.2	12.5	4.0	2.4	92.8	3.5	3.7	55.4	32.5	8.8	3.0	93.5	68.3
Tribunil	95.3	1.6	3.1	82.4	11.8	2.8	2.5	94.1	2.6	3.3	59.0	31.7	6.4	2.9	94.7	70.7
Banvel	95.6	1.8	2.6	81.5	13.4	2.7	2.4	93.1	3.6	3.4	62.9	26.9	7.3	2.8	94.3	72.2
Mean	94.9	1.8	3.3	80.0	14.1	3.3	2.5	93.2	3.3	3.6	59.3	29.1	7.1	3.0	94.0	69.9
.S.D.$_{0.05\%}$	0.8	0.5	0.6	2.4	2.0	0.9	0.8	0.9	0.6	0.7	2.4	2.4	1.3	0.9	0.8	2.4

Table 4

Means for the effect of herbicide doses on seed germination and vigour characteristics before and after aging in wheat cultivars

Dose	Before aging							After aging							Overall mean	
	Germination	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead	Germination	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead	Germination	Vigorous
	%															
1/2	93.4	2.3	4.3	74.6	18.9	4.3	2.2	92.3	3.9	3.8	53.1	35.1	8.5	2.9	92.8	63.8
1 (N.)	95.1	1.8	2.5	80.1	14.2	3.0	2.3	93.4	3.3	3.2	63.1	26.1	7.8	2.1	94.6	71.6
2	95.5	1.5	2.9	80.8	14.2	2.9	2.1	93.6	3.1	3.3	64.2	25.5	7.3	2.9	94.6	72.5
4	94.9	1.8	3.3	81.1	12.0	3.3	2.9	93.3	3.1	3.6	53.5	36.2	7.0	3.3	94.1	67.6
8	94.9	1.8	3.4	82.1	11.3	3.0	2.8	93.2	2.8	4.0	62.6	25.8	8.0	3.3	94.0	72.6
Mean	94.9	1.8	3.3	80.0	14.1	3.3	2.5	93.2	3.3	3.6	59.3	29.1	7.1	3.0	94.0	69.6
L.S.D.$_{0.05\%}$	0.6	0.4	0.5	1.9	1.6	0.7	0.6	0.7	0.5	0.5	1.9	1.9	1.1	0.7	0.7	1.9

Table 5

Means for the effect of winter wheat cultivars on seed germination and vigour characteristics before and after aging, as affected by different doses of eight herbicide applications

Cultivar	Before aging							After aging							Overall mean	
	Germination	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead	Germination	Abnormal	Dead	Vigorous	Not vigorous	Abnormal	Dead	Germination	Vigorous
	%															
Mv 4	93.6	2.0	4.3	80.1	13.0	4.3	2.4	92.5	4.1	3.4	56.5	29.3	10.8	3.0	93.0	68.3
Mv 8	95.6	1.9	2.5	86.4	8.4	3.0	2.0	94.0	2.8	3.2	66.0	25.9	5.4	2.6	94.8	76.2
Mv 9	95.5	1.6	2.9	73.4	20.9	2.6	3.0	93.0	2.8	4.1	55.4	34.0	6.9	3.5	94.3	64.4
Mean	94.9	1.8	3.3	80.0	14.1	3.3	2.5	93.2	3.3	3.6	59.3	29.1	7.1	3.0	94.0	69.6
L.S.D.$_{0.05\%}$	0.5	0.3	0.4	1.5	1.2	0.5	0.5	0.5	0.4	0.4	1.5	1.5	0.8	0.6	0.5	1.5

than twofold before aging. On the other hand, the reduction in vigour corresponded closely with increased abnormalities and dead seeds when compared after aging. In all cases, the percentage improvements in germination and vigour were the best at normal and twofold doses of herbicide treatments under the conditions of this study.

Table 5 reveals significant differences between the cultivars in germination and vigour tests before and after aging. Thus the highest means for germination and vigour percentages were found for the cultivar Mv 8.

Finally, on the basis of these results, it can be suggested that herbicides applied post-emergence provide good seed quality in winter wheat cultivars at the rates needed for acceptable weed control or at a twofold dose.

Discussion

The results of an accelerated aging test are more meaningful when compared to the results of germination and vigour tests carried out before aging. In general, this test has proved to be reasonably successful in predicting the storage life of seed lots under open storage conditions (Deleuche and Baskin 1973). There is a strong belief that a major cause of aging is protein denaturation. This may be caused by cross-linking in an individual protein molecule or by protein polymerization. Denaturation of the histone proteins of the chromosome would block DNA activation; denaturation of enzyme proteins would inactivate them, while denaturation of membrane proteins could increase the peröeability of the membranes (Harrington 1977).

Generally, Schweizer and Ries (1969) found that increased protein content in cereal seeds, arising due to an application of herbicide or nitrogen, resulted in increased seedling vigour and better germination. Nevertheless, retarding effects on seedling establishment can be assessed in terms of the resulting decrease in the measurable "germinability and number of vigorous seedlings". Inhibitory effects on the early germination phase are generally accompanied by a failure to mobilize seed reserves. The carbamates, chlorpropham and barban, as well as dichlobenil and propachlor retard the germination of grass seeds and inhibit the induction by gibberellin of α-amylase synthesis in barley endosperm tissue (Mann et al. 1967, Devlin and Cunningham 1970). Other herbicides, including 2,4-D, dicamba and bromoxynil are intermediate in their effects on both germination and proteolytic enzymes, but the correlation between the responses is not exact and probably the effect on the mobilization of storage protein is not solely responsible for the inhibition of germination (Ashton et al. 1968).

The current results showed stimulations in germination and vigour increments by doses of about normal or twofold of the minimum inhibitory dose for all the herbicides used. In this connection, the inhibition of the elongation of oat seedlings is quantitatively related to the concentration of 2,4-D, clorprophan or trifluralin in the range 0–4 parts (10^6) (Eshel and Warren 1967). Still lower doses of herbicides than those required for the inhibition of early seedling growth may have stimulatory effects (Wideman and Applely 1972). The physiological basis for such seed germination and growth stimulations by compounds which at higher concentrations have widely differing mechanisms of herbicidal action, remains obscure.

Maximum sensitivity to most growth-regulating herbicides (as opposed to photosynthetic inhibitors) is observed in the seedling establishment phase. For example, Aniten D was not inhibitory to the germination of wheat but definitely inhibited seedling growth. However, different cultivars of winter wheat showed varying degrees of sensitivity to the herbicide treatments used primarily for weed control.

Acknowledgements

The senior author thanks Dr. L. Balla, Deputy Director of the Agricultural Research Institute of the Hungarian Academy of Sciences (Martonvásár) for supplying the seed and for his helpful suggestions, and wishes to express sincere appreciation to Dr. B. Szalóczy, Director-General of the Institute for Plant Production and Qualification (Budapest) for graciously providing laboratory facilities.

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Acta Agronomica Hungarica, 37 (1–2), pp. 55–63 (1988)

INFLUENCE OF IAA AND DMAA ON HYOSCYAMINE AND SCOPOLAMINE PRODUCTION IN *DATURA STRAMONIUM* VAR. *TATULA*

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(Received: 27 June 1986)

The influence of two natural growth regulators IAA (indole-acetic acid, auxin) and DMAA (dimethylallylaminopurin, cytokinin) has been studied on the development and alkaloid production of *Datura stramonium.*

Both phytohormones seemed to accelerate the development and improve the alkaloid content. These combined effects resulted in an important increase of the alkaloid yield: 10^{-8} M DMAA and 10^{-6} M IAA seemed to have the most favourable influence.

Keywords: Datura stramonium, DMAA, hyoscyamine, IAA, scopolamine.

Introduction

Hyoscyamine and scopolamine are anticholinergic alkaloids produced by several *Solanaceae.* Both can be synthesized but the process remains economically unfavourable and therefore they are still derived from plants.

The development and alkaloid production of plants can be influenced by temperature (Elzenga et al. 1956) and light (Cosson 1969). The administration of minerals (Nowacki et al. 1974) or plant hormones (Fish 1960, Madan and Kundu 1962, James and Sciuchetti 1964, Sinha and Varma 1974, Gupta and Madan 1975) also affects the growth of the plants and the alkaloid synthesis.

In our investigations we used *Datura stramonium* var. *tatula* L. Torr. and studied the effect of different IAA and DMAA concentrations (10^{-4}, 10^{-6} and 10^{-8} M) on the development and alkaloid content of the plants.

We also tried to find out whether these growth substances directly influenced the rate of alkaloid synthesis or whether they acted indirectly via their effect on the development of the plants.

Material and Methods

Culture method

Datura stramonium var. *tatula* L. Torr. seeds (National Botanical Garden, Meise) were incubated for 2 hours in de-ionised water and sown in pots on vermiculite (3 plants/pot). The plants were cultivated in a phytotron (60% RH; 16/8 h day/night light cycle; 23/15 °C day/night

Table 1

Composition of the macro elements in the treatments

$A + C = ^{(1)} 40\ meql^{-1}$			$A/C = 0.94$ $(pH = 6.2 \pm 0.1)$		
NO_3^-	SO_4^{2-}	$H_2PO_4^-$	K^+	Ca^{++}	Mg^{++}
60	20	20	20	60	20

temperature). The hormones were first dissolved in 0.3% ethanol. We applied 6 hormonal treatments (10^{-4}, 10^{-6} and 10^{-8} M IAA and DMAA) and one control solution (0.3% ethanol; pH 7.1 $\pm$ 0.1). The pH of the 10^{-4} M IAA solution had to be adjusted with TRIS. After 2 weeks we administered a mixed solution of hormone, major elements (Demeyer and Dejaegere 1986) (Table 1) and minor elements (Johnson 1957) (Table 2). The pH of the composed solution with 10^{-4} M IAA no longer had to be corrected with TRIS.

Table 2

Composition of the micro elements in the treatments

KCl_3	0.0500 mM
H_3BO_3	0.0250 mM
$MnSO_4 \cdot H_2O$	0.0020 mM
$ZnSO_4 \cdot 7\ H_2O$	0.0020 mM
$CuSO_4 \cdot 5\ H_2O$	0.0005 mM
H_2MoO_4	0.0005 mM
Fe-EDTA	0.0200 mM

Harvest

Samples (9 plants/treatment) were taken every 4 weeks during 24 weeks.

The leaves, stems and roots were dried separately at 45 °C for 72 hours (Gupta et al. 1973) and the dry weight of the leaves and the stems was determined (in the case of the roots it was impossible to remove the vermiculite withour loss of plant material).

The dried plant material was stored in the dark at 4 °C in polyethylene flasks in the presence of $CaCl_2$.

Extraction and determination of hyoscyamine and scopolamine content

We used a modification of methods described by Parker et al. (1963) and Cosson and Vaillant (1976) as already reported by Demeyer and Dejaegere (1986).

$\pm$1 g dried and powdered sample was extracted with methanol in a "Soxhlet" for 5 hours together with the internal standard homatropine (SIGMA).

The extract was evaporated, acidified with 10 ml 0.1 N H_2SO_4 and extracted with 10 ml CCl_4.

After separation, the CCl_4 fraction was removed and the water layer was basified with 1 ml 25% NH_3 and extracted with 10 ml $CHCl_3$.

The $CHCl_3$ fraction was concentrated in a serum flask.

1.0 μl sample was injected in a 120 DFL "Intersmat Gas Chromatograph", equipped with a flame ionisation detector (glass spiral tube 1.5 m $\times$ 6.35 mm i.d., fixed carrier varaport 30 100/120 mesh, steady layer 5% SE-52, carrier gas N_2 37 ml/min, injection temperature 270 °C, column temperature 230 °C, detection temperature 240 °C).

Each sample was injected 3 times and the chromatogram was drawn by a "Tarkan W + W Recorder 600".

The peak areas were calculated with a "Hewlett Packard 3370 A Integrator".

Results and discussion

Growth and development

The phytohormones already seemed to influence the germination. In general the lower concentrations (10^{-6} and 10^{-8} M DMAA and IAA) accelerated the germination, as compared with the control, while the higher concentration (10^{-4} M) had little or no effect (Figure 1). Mayer and Poljakoff-Mayber (1966)

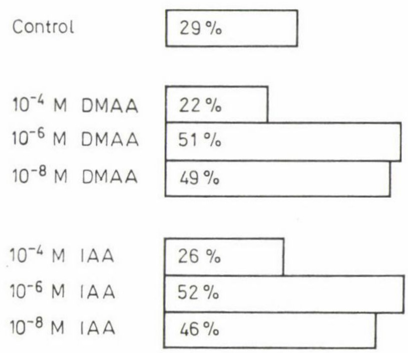

Fig. 1. Influence of the treatments on germination after 4 weeks (%). In comparison with the control, the lower hormonal concentrations (10^{-6} M and 10^{-8} M) accelerated the germination while the higher concentration (10^{-4} M) had little or no effect

noticed a similar influence of kinetine on the germination of seeds and attributed this to an increased seed sensibility for light.

For IAA the data found in literature are contradictory and seem to depend upon the hormone concentration; species, temperature and light. We should also consider the possibility of interactions between IAA and DMAA that can be synergetic or antagonistic.

For the remainder of this discussion, the results are restricted to the observations of the leaves. In general neither of the plant hormones affected the dry weight during the first 20 weeks of the experiment (Fig. 2 and 3). Thereafter the control plants stopped growing while the treated plants grew further.

The same effect was also observed by Sinha and Varma (1974) in *Datura innoxia* treated with IAA. Auxins normally promote cell elongation.

During the first weeks of the experiment the plants treated with 10^{-4} M IAA showed a retardation in their development. This effect gradually disappeared with time.

During the first 2 weeks after sowing however, TRIS was used to adjust the pH of this treatment. The buffer possibly retarded the development of the plants as it is known to inhibit the action of IAA on cell elongation

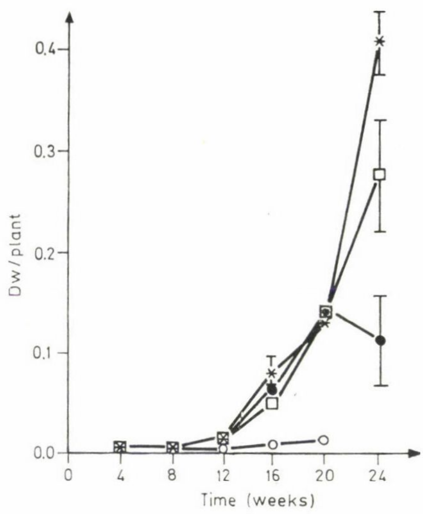

Fig. 2. Dry weight of the leaves as a function of time for the DMAA treatments. The hormone did not affect the dry weight during the first 20 weeks. Thereafter the control plants stopped growing while the DMAA treated plants grew further. 10^{-4} M DMAA remained toxic during the whole experiment

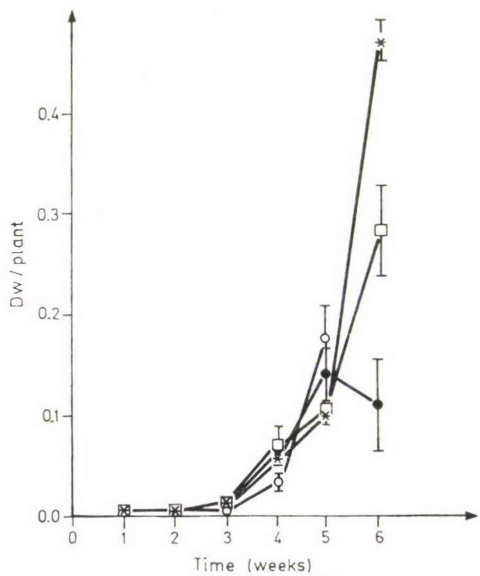

Fig. 3. Dry weight of the leaves as a function of time for the IAA treatments. IAA did not affect the dry weight until after 20 weeks. Then the control plants stopped growing while the IAA treated plants grew further. The 10^{-4} M IAA treated plants showed a retardation in their development during the first weeks, but this effect disappeared with time

(Kholdebarin 1981). In the case of the cytokinin our observations seemed contradictory with those of Luanratana and Griffin (1980) who did not find any influence of kinetine. BAP or DMAA on the growth of a *Duboisia* hybrid. However, their experiment lasted for 16 weeks while we only observed a significant influence after this period. Smith and Van Staden (1978) suggested that the cytokinins may have an effect by interacting with internal gibberellins.

In our experiment we also noticed that 10^{-4} M DMAA remained toxic during the whole investigation. This observation was also made by Hall (1973) who reported that high cytokinin concentrations inhibit the growth of plant cells.

Between IAA and DMAA there were no significant differences. For both hormones the highest crop yield was obtained with 10^{-8} M.

It is important to mention also the fact that for all treatments most of the flowers desiccated before developing their fruit. Instead the plants immediately started branching. This was probably due to the 16/8 h day/night light cycle we set up, as such an effect was also observed with *Datura innoxia* (Cosson 1969).

Alkaloid Content

Again only the results for the leaves are given. Figures 4, 5, 6 and 7 show that for all treatments scopolamine remained the main alkaloid.

In young *Datura stramonium* plants scopolamine normally dominates, but at the stage of flowering the hyoscyamine content increases while the scopolamine content decreases continuously. Finally the ratio hyoscyamine/scopolamine reverses to hyoscyamine.

In our experiment however, scopolamine remained the most important alkaloid. This was probably caused by the light cycle (16 h "light" — 8 h "night") we used.

As already cited, most of the flowers desiccated and never reached maturity. We assume that the light cycle did not directly influence the scopolamine content, but that this content is correlated with the stage of flowering. Normally the epoxydation of hyoscyamine to scopolamine lessens at this period. However, due to the light cycle, very few flowers developed and so the epoxydation continued. This could explain the rise of the scopolamine content until the end of our experiment. The increase of the scopolamine content caused by a 16/8 h day/night light cycle was also observed by Cosson (1969) and Cosson et al. (1978).

The temporal decrease of the hyoscyamine and scopolamine content in the leaves of the control plants between the 8th and the 12th week was correlated with an increase of the hyoscyamine content in the roots. We assume that the production of alkaloids kept on but that their translocation to the upper plant parts was reduced, eventually connected with a degradation in the stems and/or in the leaves.

After this period the alkaloid content rose again in the leaves of the control plants, but after 20 weeks the hyoscyamine content decreased again

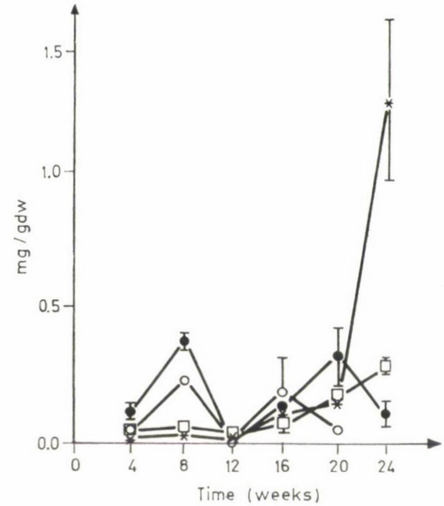

Fig. 4. Hyoscyamine content in the leaves for the DMAA treatments. In general the hyoscyamine content kept on rising until the end

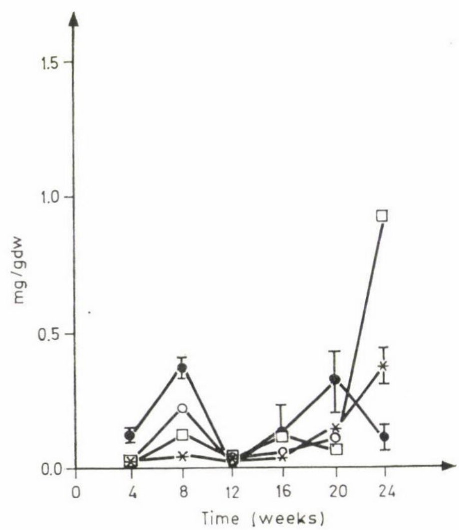

Fig. 5. Hyoscyamine content in the leaves for the IAA treatments. During the first weeks of the development the IAA treated plants used all energy and glutamic acid for their growth. Later they spent the excess of energy and glutamic acid for the production of alkaloids

in the whole plant. Since this was correlated with a reduced development, we suppose this was a result of a decreased synthesis.

In general for DMAA the hyoscyamine content (Figure 4) and the scopolamine content (Figure 6) kept on rising until the end. Since cytokinins are known to keep up the metabolism of the plant and retard the leaf senescence, the increased content could be due to an enlarged synthesis as well as to a faster translocation (transpiration). A similar influence of cytokinins on the alkaloid content was also observed by Luanratana and Griffin (1980, 1982).

For IAA the hyoscyamine and scopolamine content remained less than those in the control plants until the 20th week (Figures 5 and 7). This indicated an overall decreased synthesis. At the end of the experiment the alkaloid content rose again in the whole plant. This effect was also noticed by Sinha and Varma (1974) in *Datura innoxia*. Jonas (1969) suggested that IAA increases the supply of energy in the plant by influencing the pentose phosphate pathway. Moreover IAA promotes the glyoxylate cycle which means that the glutamic acid content increases. By way of ornithine the synthesis of alkaloids can also be enlarged.

Young plants use all available energy for their growth. In good conditions, adult plants have enough reserves so that they keep on growing and producing secondary metabolites at the same time. If IAA promotes the pentose phosphate way and the glyoxylate cycle, there will be an evolution during the development. During the first weeks of their development, the IAA treated plants use all energy and glutamic acid for their growth. Later, when the reserves are large enough, they spend the excess of energy and glutamic acid for the production of alkaloids. This is what we noticed in our experiment.

Alkaloid Yield

Both growth regulators improved development as well as alkaloid content. These effects resulted in a remarkable increase of the total alkaloid yield

Table 3

Total alkaloid yield (hyoscyamine + scopolamine) in the leaves

Treatment	Total alkaloid yield (μg/plant $\pm$ σ_m)
Control	404.982 $\pm$ 82.144
10^{-4} M DMAA	6.253 $\pm$ 0.005
10^{-6} M DMAA	839.900 $\pm$ 263.007
10^{-8} M DMAA	1812.178 $\pm$ 184.324
10^{-4} M IAA	206.702 $\pm$ 1.143
10^{-6} M IAA	1386.450 $\pm$ 269.704
10^{-8} M IAA	885.504 $\pm$ 260.711

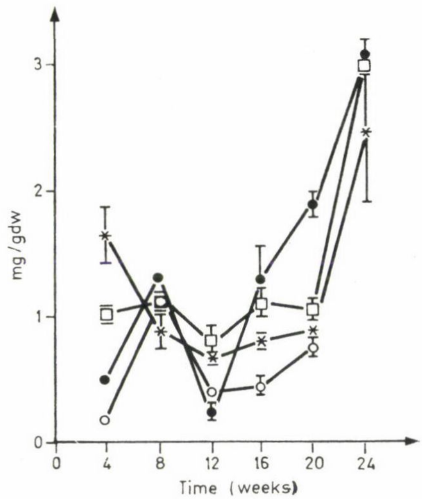

Fig. 6. Scopolamine content in the leaves for the DMAA treatments. Scopolamine remained the main alkaloid during the whole experiment. The scopolamine content rose until the end, while normally the epoxydation lessens at the stage of flowering (20th week)

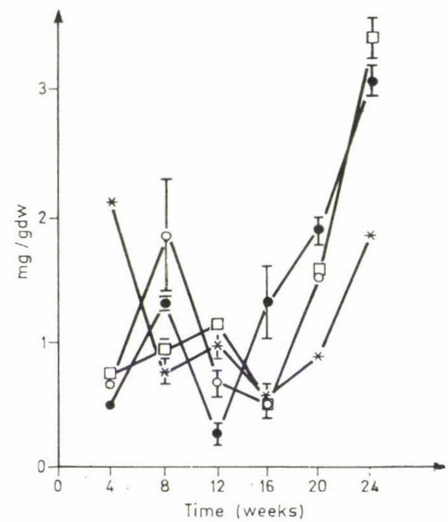

Fig. 7. Scopolamine content in the leaves for the IAA treatments. Scopolamine remained the most important alkaloid. The young plants first used their energy and glutamic acid for their development, while the adult plants had enough reserves to produce alkaloids at the same time

✳——✳ 10^{-4} M DMAA, □——□ 10^{-6} M DMAA, ★——★ 10^{-8} M DMAA, ●——● control (Figs 2, 4 and 6)

✳——✳ 10^{-4} M IAA, □——□ 10^{-6} M IAA, ★——★ 10^{-8} M IAA, ●——● control (Figs 3, 5 and 7) (hyoxcyamine + scopolamine). Table 3 shows that 10^{-8} M DMAA increased the total alkaloid yield with a factor 4.5, 10^{-6} M IAA improved it more than 3 times.

We may thus conclude that the administration of IAA and DMAA led to an important increase of the alkaloid production in *Datura stramonium* var. *tatula*.

Acknowledgements

Gratitude to Prof. Dr. R. Dejaegere and Prof. Dr. L. Neirinckx. Special thanks to K. Demeyer.

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Acta Agronomica Hungarica, 37 (1–2), pp. 65–69 (1988)

ALLELOPATHIC ACTIVITY OF *CIRSIUM ARVENSE* (L.) SCOP. IN HUNGARY

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(Received: 21 April 1986)

Field observations have indicated that the recent build-up of certain weed species can be attributed to allelopathic activity. This finding was supported by laboratory studies of *Sorghum halepense* a few years ago. The objective of the present research was to examine the allelopathy of *Cirsium arvense* on wheat, barley, lucerne and cucumber. Wheat and barley seedlings treated with extracts from the roots and foliage of the weed showed a significant inhibition in the growth of coleoptil and seminal rootlets. The radicle growth of lucerne and cucumber was also checked. Significant inhibition of germination was only found in lucerne. The extracts also lowered the rate of top growth and dry matter production of young wheat plants.

Keywords: *Sorghum halepense*, *Cirsium arvense*, allelopathy.

Introduction

Chemical weed control has become a common practice in Hungary during the past few decades. Regular herbicide treatments have resulted in considerable changes in weed population: the diversity of weed species has lowered, while some species, particularly perennials, have built up to a great extent. It is assumed that in addition to tolerance and resistance to herbicides, allelopathy also plays an important role in the build-up of certain weeds, because allelopathic species may have even the greater advantage over other plant species, as the latter being stunted by herbicides can be more easily killed by ellelopathic chemicals.

Observing phytosociological changes in weed populations, it was found that interspecific effects of certain successful species can be attributed to allelopathic activity. Species thought to be allelopathic are as follows: *Sorghum halepense* (Johnsongrass), *Cirsium arvense* (Canadian thistle), *Abutilon theophrasti* (velvetleaf), *Cynodon dactylon* (Bermuda grass), *Conyza canadensis* (Canadian fleabane) and *Digitaria sanguinalis* (hairy finger-grass). These observations are supported by the results of extensive experimental work (Bieber and Hoveland 1968, Bendall 1975, Bhowmik and Doll 1982, Horowitz and Friedman 1971, Kobayashi et al. 1980, Schreiber and Villiams 1967).

Allelopathy tests and results

Johnsongrass (*Sorghum halepense* L. Pers.) was the first of the above species tested in the laboratory to bear out its allelopathic activity (Mikulás 1981). Phytotoxic extracts from the rhizomes of Johnsongrass were studied using redroot pigweed and maize as the test species. The germination percentage of pigweed seeds treated with rhizone extracts was lowered as well as that of redroot pigweed seeds germinating on rhizome slices. The extracts also caused malformations on the seedlings. The growth of maize seedlings was significantly inhibited by the extracts. The growth of maize roots was checked to a greater extent than that of maize tops. A considerable drop in the dry matter production of the treated plants was also observed. The rate of inhibition increased with an increasing concentration of the extracts.

In the allelopathy test of *Cirsium arvense* great use was made of experiences gained in the allelopathy test of Johnsongrass.

The phytotoxicity of extracts from Canadian thistle [*Cirsium arvense* (L.) Scop.] was studied using wheat, barley, lucerne and cucumber seeds. The extracts from foliage and roots were applied in different concentrations (25.50 and 100%). Their effect on the root growth of the test species is shown in Fig. 1. It can be seen that the extracts were most effective on the radicle growth of lucerne. Treated with the most concentrated foliage extract, lucerne showed a 70% drop in radicle growth.

Extracts were also very effective on the growth of the seminal roots of wheat. The rootlets of wheat plants germinating in 100% foliage extract were 50.6% shorter than those of the control plants.

Table 1 shows the effect of extracts from *C. arvense* on the coleoptil growth of wheat and barley. Wheat proved to be much more susceptible to the extracts than did barley. The length of the coleoptil of wheat treated with the extracts was 71.3% shorter than that of control plants.

Table 1

Effect of extracts of Cirsium arvense on the coleoptil growth of wheat and barley

(coleoptil lengths, mm, 72 h after germination)

Test plants	Concentration of extracts (%)	Part of plant extracted			LSD	
		Foliage	Root	Control	$P < 0.05$	$P < 0.01$
Wheat	25	25.6	33.0	33.4	2.85	—
	50	22.4	29.2		3.21	3.12
	100	9.6	18.4		2.10	3.47
Barley	25	10.7	10.8	11.8	—	—
	50	8.0	8.3		1.98	3.05
	100	7.9	7.7		2.34	2.40

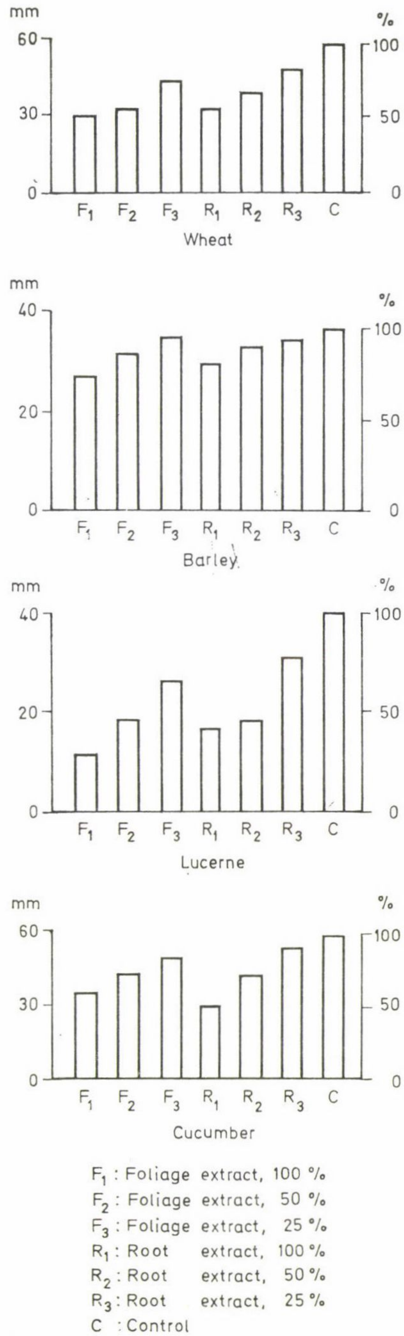

Fig. 1. **Effect of extracts of *C. arvense* on the growth of radicle/seminal roots of the test species. The left scale indicates the length of roots in terms of millimetre while the right scale indicates it as a percentage of the control**

Table 2

Effect of extracts of Cirsium arvense on the dry matter production of wheat
(Dry weight, cg, 13-day-old plants)

Plant parts	Concentration of extracts (%)	Part of plant extracted			LSD	
		Foliage	Root	Control	$P < 0.05$	$P < 0.01$
Roots	25	7.5	9.0		1.62	—
	50	6.5	8.0	9.4	2.20	1.30
	100	7.0	7.3		0.74	1.34
Top	25	5.8	6.1		—	—
	50	5.1	5.5	6.2	1.01	—
	100	4.6	5.0		1.48	1.14

The number of seminal roots produced by wheat and barley germinated in extracts was lower than that of control plants. After 7 days of incubation the germination percentage of the seeds was recorded. A significant inhibition of germination was found in lucerne. The percentage of seeds not germinated due to the extracts was as high as 35.5%. No significant difference was observed between the treated and control plants in the germination of wheat and cucumber.

The effect of *C. arvense* extracts on the top growth and dry matter production of young wheat plants was also studied. Nutrients and water was provided for the plants from a nutrient solution containing extracts in different concentration. The rate of inhibition of top growth increased with increasing the concentration of the extracts. The higher concentrated extracts were applied, and the lower rate of top growth occurred.

The rate of inhibition increased with the increasing concentration of the extracts in all tests. On an average extracts from foliage proved to be more effective than those from roots; therefore it was concluded that greater amounts of phytotoxic metabolites are contained in the leaves than in the roots. Of the test species, lucerne was most seriously affected by the extracts.

These findings are also supported by the results of Wilson (1981), who reports that, of several crop species, lucerne was found to be most susceptible to the extracts of *C. arvense.*

The above results suggest, that allelopathic agents contained in *C. arvense* may play an important role in the recent build-up of this noxious weed.

Investigations continue to obtain further information on the allelopathy of *C. arvense* and other weed species.

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Acta Agronomica Hungarica, 37 (1–2), pp. 71–74 (1988)

Plant genetics

THE IDEAL HARVEST INDEX FOR FORAGE MAIZE (*ZEA MAYS* L.) UNDER CONTINENTAL CLIMATE

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(Received: 18 March 1986)

Under a continental climate, an investigation of the effect of harvest index on the starch value or energy concentration indicates that the ideal silage maize hybrid needs at least 30% kernel proportion. Above this value the main objects of breeding would be for higher dry matter yield and the better digestibility of vegetative plant parts.

Keywords: Continental climate, harvest index, starch value or energy concentration, *Zea mays*

Introduction

The opinions of researchers working under different climate conditions differs concerning the ideal harvest index. Perry and Caldwell (1969), Bunting (1976) found that there is no need for any grain. The assimilates are stored in the vegetative plant parts in a similarly well-digestible form, as in the kernel. Smith et al. (1963), Fisher et al. (1968) emphasize the importance of a high kernel proportion even at the expense of dry matter yield. This can be attributed basically to the climatic conditions, primarily to light and temperature conditions (Hillis and Swain 1957, Statford 1964, Deinum and Dirven 1971). Lignin develops only in a restricted quantity at lower radiation and temperature, therefore it does not inhibit the digestibility of structure carbohydrates and other chemical components.

Our specific objective was to determine the harvest index region, below which the starch value or energy concentration of forage, decreases significantly in order to obtain new ideas for silage maize breeding under a continental climate.

Material and methods

In the earlier similar studies different genotypes were used to represent the harvest index variations (Gallais et al. 1976, Wermke and Theune 1980). In other research studies the harvest index treatments were carried out by removal or addition of the ears at harvest stage, and change of the harvest height and different plant densities (Fisher et al. 1968, Andrien and Demarquilly 1974, Cummins and Burns 1969, Phipps et al. 1981, respectively).

On considering the problems of the above investigators, we obtained our harvest index treatments using the same genotype [(W64A×A632)-F5Fix)] and the same plant density (4 plant/m), isolating ear primordia of 0.0%, 75.0%, 50.0% and 25.0% of whole plant number by hand, on the population level. If the different harvest index variations were obtained by having different genotypes, or by the mentioned artificial manipulations, the digestibility of the whole plant was influenced not only by kernel proportion, but also by the presumably different digestibility of vegetative parts. On the other hand, in the case of removing and adding the ears at harvest stage, the harvest index was influenced artificially, so the plant was unable to translocate assimilates to the other plant parts.

Our statements are based on one hand upon field trials, using above-mentioned treatments, and on the other hand upon animal tests.

Field trials were carried out at the Ságvári (Research Station of Cereal Research Institute in Szeged) in 1982 and (at the Research Station of the University in Mosonmagyaróvár) in 1983, without replication, because the main goal was to obtain enough forage for animal experiments. The planting times were 28th of April and 3rd of May 1982 and 1983 respectively, with a row distance of 70 cm. Three seeds were sown per hole by a handgun. The thinning was carried out at the 6–8 leaf stage, leaving only one plant per hole. Harvesting took place at 30% whole plant dry matter content, using a Plotmaster Universal Hydrostatic 2R combine and obtaining an excellent mixture of plant yield.

Each treatment was put into a plastic container and after fermentation was used to determine the *in vivo* digestibility with sheep. This process was based on the examination of differences between the fed forage, and the faeces plus the urine, in their chemical content.

Six 45–50 kg sheep were fed on each treatment, first for a ten-day training period followed by a ten-day experiment period. Crude protein, crude fiber, crude fat, ash and N-free extract were determined. On one hand the *in vivo* digestibility was based on the previously mentioned determination of forage, faeces and urine. On the other hand, the chemical components of forage were used at starch value calculation. The starch value of different treat-

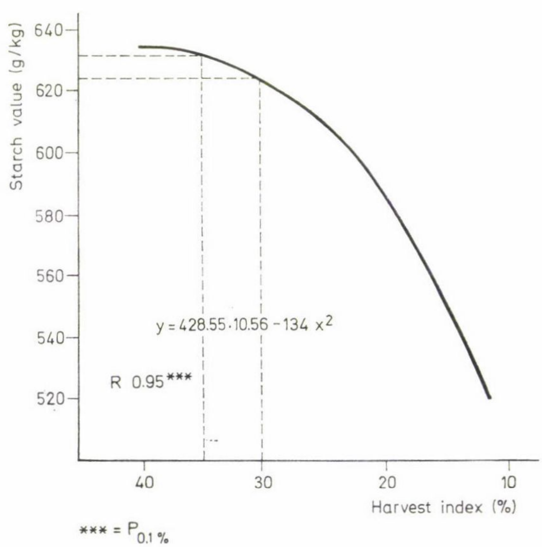

Fig. 1. **Effect of harvest index on the starch value**

ments has contained the in vivo digestibility of the above chemical components according to their various treatments and chemical figures. So the differences in starch value originate from both the differences of *in vivo* digestibility and the differences of chemical values.

Results and discussion

According to Fig. 1 the starch value or energy concentration of silage is practically the same if the harvest index of forage decreases from 40% to 35%. In this case the smaller quantity of nutritive value of assimilates accumulated in grain yield can still be counterbalanced by the better nutritive value of vegetative parts.

Under our continental climatic conditions, even a kernel proportion of 30% can be accepted if it results in a significant increase of dry matter yield. The results emphasize that, below this harvest index, the starch value or energy concentration decreases significantly.

Our conclusion agrees with those of Fairey (1980), Deinum and Bakker (1981), Vattikonda and Hunter (1983); that is, the digestibility of vegetative plant parts is very important from the standpoint of silage maize breeding, but we have to stress that the ideal type of forage maize needs at least 30% grain proportion.

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Acta Agronomica Hungarica, 37 (1–2), pp. 75–79 (1988)

FACTOR ANALYSIS IN A COLLECTION OF SMALL-SEEDED SOYBEAN [*GLYCINE MAX* (L.) MERILL] GROWN IN INDIA

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(Received: 2 August 1985)

These genotypes of *Glycine max* have an invariably indeterminate and spreading growth habit, and exhibit variation in maturity, seed size and seed coat colour. Nevertheless, these genotypes possess better germinability, palatability, and can be grown even under environmental stress conditions.

Keywords: *Glycine max* (L.) Merill., factor analysis, genotype variation.

Introduction

Although there is no available record as to when soybean was introduced in India, it has been traditionally grown in Northern hills and several other scattered pockets in the country for many centuries (Bhatnagar 1980). It has been known by various colloquial names such as Bhat, Bhatman, Bhatmas, Bhut, Kalitur, Kalikuthi, Teliakulth, Garrakalay, etc. (Singh and Mittal 1970). These genotypes have an invariably indeterminate and spreading growth habit and exhibit variation in maturity, seed size and seed coat colour. Nevertheless these genotypes possess better germinability, palatability, and can be grown even under environmental stress conditions. Small-seeded soybean has remained neglected in the past as an object of genetic studies and plant improvement. Selection is one of the important tools in the hand of a plant breeder to bring about genetic improvement by changing the gene frequency. It is difficult for a breeder to take into consideration all the agronomic, morpho-physiological and quality traits, while going for selection. Hence, a comparatively small number of important traits accounting for maximum variability must be found for making effective and reliable selection. Furthermore, small-seeded genotypes are being replaced by the primary and secondary introductions from USA. Despite genetic erosion, available small-seeded soybean collections are still diverse in agro-botanical traits. Therefore, it is necessary to spot characters which reflect the greater proportion of variation among the available small-seed soybean genotypes.

Material and methods

The resolution of a large number of variables linearly related in terms of a small number of variables, can be accomplished with factor analysis. It is a statistical technique, which reduces the dimensions of multivariate data by removing intercorrelations among attribute-variables, and enables multidimensional relationships to be plotted on 2 or 3 principal axes (Harman 1967). It also chooses independent or orthogonal axes, which are minimally correlated and represents linear combination of original characters (Clifford and Stephenson 1975). The relative discriminating power of axes and their associated characters are measured by eigenvalues and factor scores respectively.

Forty-five accessions of small-seeded soybean representing a broad spectrum of diversity were selected from the germplasm collection, being maintained at Himachal Pradesh Agricultural University, Palampur. The genotypes were grown in a randomised block design with three replications. Each entry had two rows 3 m long with inter and intra-row spacings of 50 and 5 cm, respectively. In each plot, five plants were selected at random for recording observations. The characters studied were days to flowering and maturity, plant height (cm), branches/plant, pods/main stem, pods/branches, total pods/plant, pod clusters/plant, pods/cluster, seeds/plant, 100-seed weight or seed index (g), harvest index (%), oil (%), protein (%) and seed yield/plant (g). Oil and protein contents were determined on a random seed sample representing each entry. Oil (%) was estimated with the Nuclear Magnetic resonance Spectrometry (Tiwari et al. 1974). The estimation of protein content was based on the optical density measurements on Technicon Auto-analyser-II (Technicon Instruments Corporation, Terrytown, New York, USA).

The data were tested for the existence of variability for different traits. The significant traits were correlated in all possible combinations at the phenotypic level as suggested by Al-Jibouri et al. (1958). Correlations were used for factor analysis through principal component method (Harman 1977). The analysis was terminated after the factors accounting for more than 90% variability were extracted. Factors having eigenvalue of at least unity were retained and ranked in the order of their eigenvalues. Traits affected by these factors were arranged in the order of their relative factor loadings.

Results and discussion

Range, mean values, phenotypic coefficient of variation and mean sum of squares are presented in Table 1. The phenotypic coefficient of variation under study revealed the presence of wide diversity in the material under study. All the traits other than oil (%) and protein (%) were found to be significant.

Seed yield/plant was found to be associated with branches/plant, pods/main stem, pods/branches, total pods/plant, pod clusters/plant and seeds/plant (Table 2). These seed yield components were also found to be associated with each other. Seed yield did not show any association with days to flowering and maturity, and plant height, which were all positively associated with each other. Pods/cluster, seed index and harvest index have nothing to do with the enhancement of seed yield.

The factor analysis divided 13 significant variables into three factors (Table 3). Factor I accounted for more than 50% of the total variability, while factor III explained less than 15%. The communality or amount of variation of a character accounted for all factors taken together, were found to be ranging from 49.17% (seed index) to 98.85% (pod clusters/plant). Factor I recorded the highest factor loading on pods/branches, followed by pods/

Table 1

Range, mean, phenotypic coefficient of variation and mean sum of squares for different characters in small-seeded soybean

Character	Range	Mean	Phenotypic coefficient of variation	M.S.S.
Days to flowering	41.0– 96.2	60.6 ± 10.2	22.5	547.0**
Days to maturity	81.0–159.6	110.4 ± 22.5	29.6	1396.3**
Plant height (cm)	27.0– 75.3	50.0 ± 9.1	29.3	495.0**
Branches/plant	3.0– 9.5	5.9 ± 1.1	32.9	7.8**
Pods/main stem	2.1– 12.9	8.3 ± 1.8	39.6	16.7**
Pods/branches	9.3– 50.6	23.5 ± 4.3	46.4	198.8**
Total pods/plant	15.9– 59.5	30.9 ± 6.8	40.7	214.7**
Pod clusters/plant	10.7– 29.1	19.8 ± 2.9	33.9	119.3**
Pods/cluster	1.1– 2.3	1.6 ± 0.2	23.9	0.3*
Seeds/plant	32.0–155.3	65.0 ± 8.1	55.9	2052.2**
Seed index (g)	4.6– 8.4	5.9 ± 0.4	18.7	2.3**
Harvest index (%)	28.7– 64.0	42.4 ± 7.1	22.5	159.9**
Oil (%)	16.7– 21.0	18.5 ± 1.2	6.1	6.2
Protein (%)	37.7– 44.2	37.8 ± 1.6	7.5	2.9
Seed yield/plant (g)	2.0– 6.0	3.7 ± 0.9	43.2	22.84**

* Significant (p = 0.05)
** Significant (p = 0.01)

plant, branches/plant, plant height, days to maturity, seeds/plant, pod clusters/plant and days to flowering. Thus, the first factor was regarded as combination of structural and phenological traits. As expected, the traits in this factor were mutually correlated and the lowest correlation value ($r = 0.282^{+}$) affected was between days to maturity and pods/cluster. The traits included in this factor were mainly the components of seed yield. Factor II, comprising harvest index and pods/main stem explained 25.06% of total variation. Pods/plant, seeds/plant and pod clusters/plant besides being the important traits of factor I, were also affected by factor II. The contribution of days to flowering and maturity, and plant height to this factor was negative. Harvest index also exhibited a negative correlation with days to flowering ($r = 0.457^{++}$), days to maturity ($r = -0.353^{++}$) and plant neight ($r = -0.386^{++}$). Thus, an increase in the strength of this factor, would tend to lead to a reduction in the days to flowering and maturity, and plant height. Factor III accounted for 14.52% of the total variability. This factor was made up of pods/cluster and seed index. Pods/plant, seeds/plant and pod clusters/plant were affected by factors I and II simultaneously, while pods/main stem was affected by factors II and III.

The correlation co-efficient did not indicate the role of days to flowering and maturity, and plant height for seed yield/plant (Table 2). However, factor

Table 2

Phenotypic correlation coefficients between

Character	Days to maturity	Plant height	Branches/plant	Pods/main stem	Pods/branches
Days to flowering	0.687**	0.526**	0.498**	−0.144	0.183
Days to maturity		0.617*^{3}	0.542**	−0.103	0.384**
Plant height			0.727**	0.017	0.591**
Branches/plant				−0.133	0.723**
Pods/main stem					0.229
Pods/branches					
Total pods/plant					
Pod clusters/plant					
Pods/cluster					
Seeds/plant					
Seed index					
Harvest index (%)					

* $P < 0.05$; ** $P < 0.01$

analysis revealed the importance of these three traits as these were affected by the first factor. Thus, correlation study and factor analysis provided complementary ways of studying the data. Such information will assist the breeder

Table 3

Factor analysis in small-seeded soybean

Variable	Factor I	Factor II	Factor III	Communality (%)
Factor I				
Pods/branches	0.907	0.297	−0.093	96.03
Pods/plant	0.838	0.410	0.149	95.32
Branches/plant	0.824	−0.315	−0.117	79.27
Plant height	0.778	−0.369	−0.091	75.05
Days to maturity	0.750	−0.311	0.039	69.47
Seeds/plant	0.639	0.511	0.065	79.55
Pod clusters/plant	0.602	0.620	−0.491	98.85
Days to flowering	0.555	−0.599	0.058	73.70
Factor II				
Harvest index	−0.460	0.584	0.075	56.70
Pods/main stem	−0.036	0.397	0.674	61.58
Factor III				
Pods/cluster	0.412	−0.216	0.660	65.19
Seed index	−0.019	−0.304	0.400	49.17
Eigenvalue	5.17	2.43	1.50	—
Variation (%)	53.32	25.06	14.52	—
Cumulative variation (%)	53.20	78.38	92.90	—

various traits in small-seeded soybean

Total pods/plant	Pod clusters/plant	Pods/cluster	Seeds/plant	Seed index	Harvest index (%)	Seed yield/plant
0.125	−0.056	0.299*	0.061	0.076	−0.457**	0.057
0.305*	0.131	0.282**	0.333*	0.100	−0.353*	0.176
0.514**	0.372**	0.350*	0.271	−0.097	−0.386**	0.269
0.589**	0.467**	0.371*	0.312*	−0.100	0.285*	0.408**
0.473**	0.260	0.479**	0.210	0.002	0.211	0.337*
0.892**	0.798**	0.347*	0.517**	−0.222	−0.104	0.545**
	0.760**	0.461**	0.515**	−0.152	−0.010	0.559**
		−0.002	0.490**	−0.342**	0.142	0.427*
			0.193	0.126	−0.226	0.217
			0.184		0.012	0.488**
					−0.032	0.127
						0.058

both for increasing his understanding of the importance of various characters and also to determine the nature and sequence of traits for which the selections were to be made in his future breeding programme.

Acknowledgements

The author is grateful to Dr. S. K. Sinha, Professor of Eminence, Water Technology Centre, Indian Agricultural Research Institute, New Delhi, for permission to work in his laboratory and more to Dr. R. K. Koundal, Plant Biochemist, for helping in protein estimation.

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Acta Agronomica Hungarica, 37 (1–2), pp. 81–85 (1988)

Agrochemistry

APPLICATION OF ELECTRO-ULTRAFILTRATION (EUF) TECHNIQUE IN NITROGEN FERTILIZATION OF COTTON

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(Received: 28 April 1986)

The assessment of nitrogen fertilizer requirements using results of soil analysis is particularly difficult because many different factors affect N dynamics in the soil. The determination of N fractions in the soil by means of an electro-ultrafiltration (EUF) procedure improves knowledge of the N dynamics and this should serve as a basis of N fertilizer recommendations. The relationships between the EUFN fractions in the soil and the seed cotton yield are described on the basis of the EUF-N soil analysis.

Statistically significant correlations for seed cotton yield were found with EUF-NO_3, EUF-$NH_4 + NO_3$ in the soil solution. It is suggested to use extractable NO_3-N for calculation of the N fertilizer requirements. The N fertilization can also be corrected during the active growth period on the basis of petiole NO_3-N diagnostic technique.

Keywords: Fertilizer requirement, N supply rate, electro-ultrafiltration, EUF-NH_4, EUF-NO_3, petiole-NO_3-N, soil analysis fertilizer response, cotton seed yield.

Introduction

The main factors of intensive fertilization are pool fertilization i.e. reserve stock before planting and maintenance of fertilization, applied during the growth period. The amount of pool fertilization can primarily be diagnosed by soil analysis whereas plant analysis plays an important role in maintenance fertilization (Malik et al. 1984) and the amount of nutrients available (Németh and Makhdum 1981) in the soil. In this connection soil and plant analyses are both necessary for the judicious use of fertilizers.

The successful cultivation of cotton demands an ample supply of nitrogen (Ali et al. 1970). No reliable soil test is available in Pakistan to predict nitrogen supply in the course of the growing period. The main reason is that available nitrogen is difficult to measure. Electro-ultrafiltration (EUF) offers a means to predict soil nitrogen in such a way that information is available on both existing and potentially available nitrogen (Németh 1979).

Electro-ultrafiltration consists of a combination of electrodialysis and ultrafiltration. Electrodialysis had long been used to separate ions from clay minerals. This method is based on the principle of diffusion along a concentration gradient through a semipermeable membrane. Ultrafiltration is a filtration process by means of which the soil colloids are collected on a filter and sorbed ions are removed by leaching. Bechold (1925) suggested combining ultrafiltration with electrodialysis for the better fractionation of plant nutrients from soil. More recently Jung and Németh (1966, 1969) improved it to determine nutrient concentration in soil solution and its buffering in the routine soil test. The details of the method are provided by Németh (1972, 1979).

The aim of this investigation was to discover the suitability of the EUF method of soil analysis in diagnosing nitrogen needs of cotton crop. In this respect, efforts have been concentrated on NO_3-N in the soil before planting and NO_3-N concentration in the petiole (plant organ) during the growth period.

Material and methods

The soil samples in this investigation belong to alluvial soils, rich in $CaCO_3$ and are from an area practicing an irrigated agriculture.

The soil samples were derived from the top soil layer (0–20 cm) at the time of cotton planting. The soils were air dried and passed through a 2 mm sieve.

A fully automatic EUF equipment model 723 was used for the extraction of nitrogen from the soil samples. A 5 g sample of each soil, replicated 5 times, was put in the middle cell of EUF and water was used as the extractant.

(a) The soil was extracted for 20 min. at 200 V and 25 °C to obtain the readily available N fraction.

(b) The same soil was extracted at 80 °C and 400 V for 15 min. to obtain the nitrogen buffering fraction in addition to readily available N. This analysis also demonstrated the influence of increasing temperature and voltage on N extraction (Németh 1972 and 1979).

The anode and cathode filters were of types EUF 510 and EUF 511 respectively. The anode and cathode extracts were collected separately. The vacuum in the two outside chambers was adjusted so as to allow 50 ml volume of the cathode and anode extract (soil extractrinse water). The EUF NH_4-N and NO_3-N in the filtrates obtained cathodically and anodically were analysed by the micro-kjeldhal method (Jackson 1962). The other determinations were made according to methods described by U.S. Salinity Laboratory Staff (1954) and Organic Carbon by Moodie et al. (1959). The petioles of the mature leaves on the main stem (3rd or 4th from terminal) were sampled at different stages of growth from an experiment having gradient doses of nitrogen (0, 25, 50, 150 kg/ha). The nitrate nitrogen was determined by the method of Johnson and Ulrich (1959).

Results and discussion

The data on basic characteristics of soil are listed in Table 1.

Table 1 shows that soils are medium in texture and alkaline in reaction. The soils were free from any sort of impediments for deep root penetration. The soil differed greatly in their $CaCO_3$ content but had even values for total nitrogen content.

The data on EUF of soil nitrogen are illustrated in Table 2.

The data presented in Table 2 clearly demonstrate that the EUF-NH_4 contents differed at all sites, both the effectively available fraction (25 °C, 200 V) as well as the reserve EUF-NH_4 values obtained at 80 °C. It has been found that the fraction of NH_4* N increased at high temperature and voltage. The amount of effectively available NO_3-N extracted at 25 °C, 200 V were also lower than those extracted at high temperature and voltage. Németh et

Table 1

Basic characteristics of the soils (0–20 cm) used in the investigation

Sites	pH (H_2O) 1 : 10	Electrical conductivity (mmhos/cm) 1 : 5	Organic carbon (%)	$CaCO_3$ (%)	Total N (%)	Textural class
Multan	8.2	0.20	0.28	6.3	0.02	Silt loam
Bahawalpur	8.3	0.25	0.36	14.1	0.02	Sandy clay loam
Khanpur	8.3	0.40	0.32	8.0	0.02	Sandy clay loam
Thatta Gurmani	8.5	0.42	0.36	15.1	0.02	Sandy
Haroonabad	8.4	0.30	0.33	5.6	0.02	Sandy loam

Table 2

EUF-NH_4, EUF-NO_3 and EUF total-N values of alluvial soils at varying voltages and temperature (in mg N/100 g)

Sites	EUF-NH_4		EUF-NO_3		Total N	
	25 °C (200 V)	80 °C (400 V)	25 °C (200 V)	80 °C (400 V)	25 °C (200 V)	80 °C (400 V)
Multan	1.49	3.27	3.47	6.90	4.96	10.17
Bahawalpur	1.80	2.12	3.51	6.26	5.01	8.38
Khanpur	1.57	3.61	4.08	7.98	5.65	11.59
Thatta Gurmani	1.76	3.65	4.98	7.01	6.74	10.66
Haroonabad	1.90	4.48	7.28	10.20	9.18	14.68

Table 3

Co-efficient of correlation between various N fractions before planting and cotton seed yield

Sites	EUF-Nitrogen fractions at 25 °C, 200 V		cotton Seed yield (kg/ha)
	EUF-NO_3	EUF NH_4 + $+NO_3$	
	mg N/100 g		
Multan	3.47	4.96	505
Bahawalpur	3.51	5.01	577
Khanpur	4.98	5.65	588
Thatta Gurmani	4.98	6.74	640
Haroonabad	7.28	9.18	717

al. (1979) reported that the EUF-NH_4 and EUF-NO_3 values showed a marked increasing trend with the rise in voltages and temperatures . . .

The data in Table 2 raise the questions as to which N fraction could best be related to seed cotton yield. This point has been clarified in Table 3.

The EUF-NO_3-N determined in the soil samples collected from locations in Southern Punjab before cotton planting can be best correlated with seed cotton yield.

$$Y = 46.3785X + 389.1033 : r = 0.9^{**}$$

where Y = seed cotton yield, and X = EUF-NO_3-N

Data presented in Table 3 also demonstrate that the sum of EUF-NH_4 + NO_3 N can also be significantly correlated with seed cotton yield.

$$Y = 41.9659X + 340.6791 : r = 0.94^{**}$$

where Y = seed cotton yield, and X = EUF-NHq + NO_3-N

It is advisable to use EUF-NO_3-N in predicting nitrogen requirements of cotton crop because the sum of the EUF-extractable N (NH_4 + NO_3) did not improve the correlation value.

We went further in another study to use tissue of NO_3-N concentration in the cotton petiole as nitrogen supply indicator for the correction of N fertilizer during the active growth period. Any sort of excessive N fertilization at early stage may lodge, welcome insectpests and delay crop maturity or boor nutrition may cause a reduction in yield to an uneconomic level. The judicious use of N fertilization can be made on the basis of a plant analysis (Malik et al. 1984).

It is concluded from Table 4 that a suitable dose of N fertilizer can be applied in accordance with the petiole NO_3-N concentration (Malik et al. 1984).

Table 4

Nitrogen fertilizer prescription based on cotton petiole analysis

Physiological growth stage	In position petiole NO_3-N concentration (ppm)	Nitrogen fertilizer (kg/ha) added for optimum yield
Flower bud stage	8 500	100
	9 500	75
	10 500	50
	11 500	25
Bloom stage	3 500	100
	4 000	75
	4 500	50
	5 000	25

Conclusion

The nitrogen fertilizer calculations based on soil analysis should take into account nutrient concentration in the soil solution and nutrient buffering capacity, which both control the nutrient flux into roots. Electro-ultrafiltration provides the data on these aspects of soil nitrogen. The analysis of soil nitrogen fractionation by EUF can provide information on nitrogen requirements during the crop season. The NO_3-N concentration in cotton petioles can be efficiently used for corrective measures during the growing season.

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Acta Agronomica Hungarica, 37 (1–2), pp. 87–92 (1988)

ENZYME ACTIVITIES IN SOILS OF DIFFERENT FOREST ECOSYSTEMS

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In the opinion of several authors the intensity of biological processes can be well characterized by the activity of the soil enzymes, thus it can be considered as an appropriate index of soil fertility. Microorganisms produce more active enzymes than other plants. Different soil types show some differences in the quantity and species composition of the microorganisms living in them, as well as in the intensity of the biological processes due to their genetics, physical and chemical properties and differences in the ecological conditions.

The aim of our studies presented below was to contribute further data to our knowledge of the enzyme activities in soils of different forest ecosystems.

Keywords: Catalase, dehydrogenase, invertase, phosphatase, urease, protease enzymes, soils, forest ecosystems.

Introduction

The investigations have been carried out in the following ecosystems:

(1) A plantation-like spruce stand 116 years old, mixed with larch *(Piceetum excelsae cultum)* and planted on acidic, non-podzolic brown forest soil of a loamy texture and a deep tilth, being under the influence of seepage water in a beech-type microclimate. The area is 90% covered, the number of trees is 348, the share of the components in the mixture according to the number of trees: spruce 75%, larch 25%, average height 30.91 m, average diameter in breast height 41.84 cm, volume 907 m^3. Site Asztalfő.

(2) A mixed pubescent-chestnut-Turkey oak stand *(Orno-Quercetum Pubescenti-Cerris)* 77 years old of a sprout origin on black rendzina soil of shallow tilth and loamy texture, without influence of surplus water, having a chestnut-Turkey oak type microclimate. The area is 80% covered (number of trees 372, the components of the mixture according to tree numbers: Austrian oak 75%, chestnut oak 15%, average height 14.48 m, average diameter in breast height 24.73 cm, volume 213 m^3). Site Szárhalom.

(3) A natural-like beech stand *(Laureolae-Fagetum)* 104 years old on brown forest soil of a loamy texture and a shallow tilth, with clay illuviation, without the effect of surplus water, having a beech-type microclimate. It is a thinned, unmixed stand with a cover of 90% (number of trees 239, average breast height diameter 44.5 cm, volume 719 m^3). Site Farkasgyepű.

Material and methods

The study of enzyme activities covered the following:

— *catalase:* due to the effect of catalase, hydrogen peroxyde decomposes. The developing O_2 has been determined gasometrically (Galstyan 1978).

— *dehydrogenase:* as hydrogen acceptor uncoloured 2,3,5-triphenyl-tetrasolium-chloride (TTC) was used. In the presence of dehydrogenase, the latter is reduced to red coloured triphenyl-formasan (TPF) in anaerobic conditions and its quantity is then determined by colorimetry (Galstyan 1978).

— *invertase:* its determination is based on the reaction of the reducing sugars getting free from a splitting of the sacharose by 3,5-dinitro-salicylic acid. The latter is reduced to 3-amino-5-nitro-salicylic acid of a yellow-orange colour by reducing sugars when boiling. The intensity of the colour which changes depending on the invertase activity is determined by colorimetry (Scherbakova, T. A. 1968).

— *phosphatase:* the activity of the phosphatase has been determined using colorimetry, by measuring the quantity of P_2O_5 split from the substratum (Galstyan 1978).

— *urease:* under the effect of urease, cerbamide is hydrolysed into CO_2 and NH_3. The quantity of the latter is determined by colorimetry (Galstyan 1978).

— *protease:* the measurement of its activity is based on the quantitative determination of the amino acids developing by hydrolysis from the protein added to the soil. If the amino acids are heated in a water bath with ninhydrine, they turn a blue colour. The colour intensity is measured by colorimetry. The quantity of amino acids has been transformed into glycine using a nomogramme made with p.a. glycine (Chaziev 1982).

The investigation of the forest soil microflora was carried out by the method of direct microscopy using a fluorescence microscope (Zvyagintsev, D. C. et al. 1978). The results of the direct method of calculation are many times greater than that under cultivation (Pántos-Derimova, T. 1985).

The study CO_2-production of the soils was carried out by the gas-chromatographical method (Kazanskaya, T. B. et al. 1980).

Results and discussion

The data on the enzyme activity of soils are presented in Table 1, and Fig. 1. The activity of the enzymes studied was highest in the litter cover at all three sites, in accordance with the total N, P and K (Pántos et al. 1982), with the total bacterium count and with the CO_2-production (Pántos-Derimova 1983). This can be explained by the fact that the litter cover is a special organogenic layer of the forest soils, where the primary role in the transformation processes of the organic material is played by micro-organisms and by enzymes secreted by them.

The highest catalase, dehydrogenase, urease and protease activities were found in the litter cover of the pubescent-chestnut-Turkey oak stand on rendzina soil. It was followed by the soil of the thinned beech stand, and the spruce stand mixed with larch followed in third place. In the same sequence the C : N ratio of the litter cover was widening — 31.6 : 1; 32.9 : 1; 39.4 : 1 — and *Jenny's k-value* (Jenny et al. 1949) was decreasing, which characterizes the intensity of the decomposition of the organic material — 28.84; 28.66; 22.58%.

The invertase and phosphatase activities were highest in the acidic, non-podzolic brown forest soil below a spruce stand mixed with larch, fol-

Table 1

Enzyme activity in the soils

Soil type, site, horizon and sampling depth, cm		Oxyreductases		Hydrolases			
		Catalase O_2 cm^3/1 g d. m.	Dehydrogenase TPF, mg/24 h/10 g d. m.	Invertase, glucose, mg/1 h/g d. m.	Phosphatase, P_2O_5, mg/30'/100 g d. m.	Urease NH_3, mg/24 h/1 g d. m.	Protease glycine mg/24 h/1 g d. m.
Acidic, non-podzolic brown forest soil (Asztalfő)							
$A_{00}+A_0$ litter		22.6	16.9	1049.4	46.6	0.1	0.5
A	0– 25	8.1	5.3	331.3	11.0	tr	0.3
B	25– 40	0.9	2.7	139.2	10.0	tr	0.1
	40– 63	0.6	2.2	118.3	4.7	tr	0.1
	63– 90	0.3	1.8	60.7	6.1	tr	tr
C	90–110	1.9	4.1	112.8	9.6	tr	0.2
	110–120	1.7	6.0	279.5	11.2	tr	0.4
Rendzina soil (Szárhalom)							
$A_{00}+A_0$ litter		43.0	86.4	307.4	23.2	1.6	0.7
A	0– 5	13.0	21.1	157.8	13.3	0.1	0.5
	5– 15	9.6	16.6	116.2	10.0	0.4	0.5
	15– 30	7.9	18.9	117.8	14.4	0.1	0.4
	30– 50	4.8	7.3	63.0	4.9	0.4	
C	50–100	compact, sandy Leitha-limestone					
Brown forest soil with clay illuviation (Farkasgyepű)							
$A_{00}+A_0$ litter		24.9	40.8	401.7	36.0	0.5	0.6
A_1	0– 16	4.5	12.0	154.5	12.4	tr	0.5
A_3	16– 28	3.3	11.7	76.4	8.0	tr	0.2
B	28– 75	1.2	6.4	50.2	4.8	tr	0.2
C	75–103	0.6	2.2	28.9	2.6	tr	tr

D. m. = dry matter; TPF = triphenyl-formasan

lowed by the thinned beech stand and by the *pubescent*-chestnut-Turkey oak stand. The very high invertase activity in the litter cover of the spruce stand mixed with larch — about three times higher than in the litter of the pubescent-chestnut-Turkey oak stand — can be explained by a very wide C : N ratio. The very low urease activity was also connected with this wide ratio.

In the opinion of many authors (Krámer and Erdei 1959, Lundegårdh 1923) the phosphatase-activity of the soil is influenced by the number of micro-organisms synthesizing this enzyme and by the intensity of the phosphatase-producing activity of these micro-organisms. The latter depends mainly on the readily soluble phosphorous-content of the substratum. The lower this content, the higher is the phosphatase activity.

According to the present data, the readily soluble phosphorous-content in all the three litter covers was less than 0.5 mg, while the highest phosphatase-

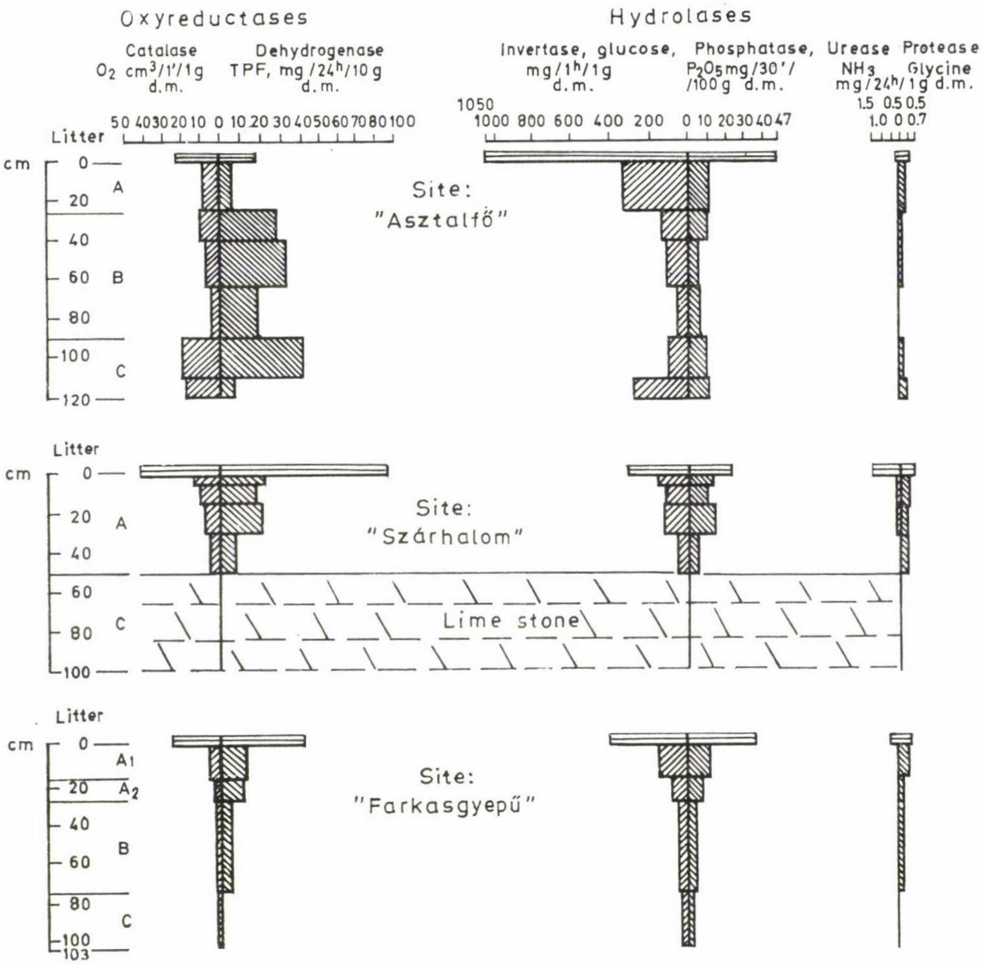

Fig. 1. Enzyme activity in soils

activity was found just in these. Its value is about 2–4 times higher than in the mineral levels immediately following them at greater depths.

In the *mineral horizons* of the acidic, non-podzolic soil and in the brown forest soil with clay alluviation, the phosphatase-activity was always higher than the quantity of the readily soluble phosphorous In the case of the rendzina soil, this is true only for the 25–50 cm depth of the *A* horizon. In our opinion this can be explained by the very high organic material content in the upper regions of this horizon.

In the *mineral horizon* of the soil, the enzyme activity nearly exactly changes following the trend showing the nutrient content from the near-surface layers toward the deeper ones.

In the case of the acidic, non-podzolic brown forest soil the enzyme activity decreased continuously until the 90 cm depth then it increased again in the *C horizon*. A small deviation occurred only in the case of the phosphatase enzyme — similarly to the quantities of readily soluble phosphorous and potassium — which showed an increase of the activity already in the 63–90 cm depth of the *B horizon*.

The changes of the activity in different layers of the soil profile can be partly expalined by the very high skeleton percentage of the *A* and *B horizons*. In consequence of the downward transfer of the organic material, decomposition starts quite quickly in addition to the transfer of the readily soluble nutrients. This process is significantly retarded in the *C horizon* and the nutrients in the soil solution are returned. Thus advantageous conditions are created for the propagation of the oligotrophic group of micro-organisms which occur according to our many investigations (Pántos-Derimova, 1983) in these horizons. It can be supposed that some species of these may also produce some of the enzymes discussed. At the same time, enzymes produced in the upper layers of the soil may also move downwards and accumulate above the clay layer of the soil-forming rock.

The continuous decrease of the dehydrogenase, invertase and phosphatase activities was present in the case of the rendzina soil from the surface, only to a depth of about 15 cm in the *A horizon*. The activity of these enzymes increased at the 15–30 cm depth.

In the mineral layer of the brown forest soil with clay alluviations, the enzyme activity decreased — similarly to the quantity of readily soluble nutrients — from the surface toward greater depths.

The differences between the enzyme activities of the mineral layers of the soil are not evaluated, as they refer to genetically different types. Thus, in case of the rendzina soil, only the *A horizon* has been studied. Furthermore, the thickness of the horizons, and within them, the thickness of the different layers are dissimilar.

The present investigations have shown that the changes in the profile of both the quantity of readily soluble nutrients and of the enzyme activity are influenced not only by the genetic soil types, but also in connection with the total effect of the site type.

Conclusions

On the basis of our findings we conclude that in all three ecosystems the investigated enzyme activities were the highest in the forest litter. In fact the forest litter constitutes a specific organogenic layer of the soils, where the transformation processes of organic matter are determined mainly by micro-organisms and the enzymes produced by them.

Catalase, dehydrogenase, urease and protease activities were found to be the highest in the forest litter of the *Orno-Quercetum pubescenti-cerris* mixed stand on the rendzina, and the lowest in that of *Piceetum excelsae cultum*, where invertase as high as that determined in the forest litter of *Orno-Quercetum pubescenti-cerris* — is due to the very wide C : N ratio. This also explains the very low urease and moderate protease activities.

The easily soluble P_2O_5 contents of the forest litters did not exceed 0.5 mg in either case, while their phosphatase activities were 2–4 times higher than the corresponding values determined in the topmost mineral soil layers.

The changes with depth in enzyme activities in the mineral soil layers closely followed those in the contents of readily available nutrients.

On the basis of our data the conclusion has been drawn that the changes in enzyme activity within the profiles are influenced not only by the soil type but also by the characteristics of the habitat type. The investigation of the transformation processes taking place in the different forest litters should always include the determination of enzyme activities.

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Acta Agronomica Hungarica, 37 (1–2), pp. 93–100 (1988)

Animal genetics

DIFFERENCES BETWEEN THE PERFORMANCE OF SOWS AND BARROWS AND ITS INFLUENCE ON PROGENY TEST RESULTS

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(Received: 4 October 1985)

Investigations were carried out by the authors to determine the differences between the fattening performances and carcass traits of pigs of different sexes (sows and barrows). The effects of these traits on the breeding value estimates were also analyzed, using the data on 2051 individuals from 4 breeds.

It was stated that the sex differences should be inevitably taken into account for the estimation of the breeding values. In Hungary, this fact is of great importance, because the progeny groups consist of sows and barrows. If the rate of sexes differ from 50 : 50% it is reasonable to adjust the data or repeat the investigations.

Keywords: Sows, barrows, breeding-values, fattening performance, carcass traits.

Introduction

Regarding the fattening performance and other parameters, there are fundamental differences between pigs of the same breed, but of different sex. These differences appear mainly in the case of sows and boars (females and males). Similarly, considerable differences can be found in the economically important traits between sows and barrows (females and castrates). In the investigations we tested the differences between sows and barrows for the most important parameters of various Hungarian breeds having large base populations. The effect of these differences in progeny tests was also investigated. In Hungary, the progeny test of breeding sows is carried out with progeny groups consisting of females and castrates.

A number of older and recent Hungarian publications: Horn (1935) Berek et al. (1982), Holdas (1960), Holdas et al. (1964), Kovács and Khanh Uac (1978), Horn et al. (1982), Csató et al. (1983) provided data on the performance differences between sexes in the older and the present day pig populations, mainly in the sub-populations of breeds. On the differences of the performance depending on sex, in foreign breeds, Copclin et al. (1981), Chorette (1958), Palenik et al. (1955), Gupta et al. (1982), Kintaba et al. (1981), Pohar et al. (1975, 1976), Standal (1977), Stoikov et al. (1982) and Wood (1982) published valuable data.

Methods

The performance data of the progeny groups, classified over one year on Hungarian progeny test stations, served as the basis for our calculations. It was possible to carry out individual evaluations because of the individual housing and survey of data. In the year of this investigation, the data on 2588 pigs were available and a detailed analysis was carried out on 2051 individuals. The 2051 pigs under examination came from the following 4 breeds: the *Hungarian Large White*, the *Estonian*, the *Swedish Landrace* and the *German Landrace* (GDR). The initial body weight amounted to 30 kg at the beginning of the trial. The final weight was 103 $\pm$ 1 kg, using ad libitum feeding. The management of the pigs was carried out in 4 progeny test stations from the beginning of the test until slaughtering, and data were recorded accoring to the Hungarian Standard No. 6805.

Results

The average values of growth performance and feed conversion traits for breeds and sexes are given in the Tables 1 and 2. From the data it may be stated that:

— The age of pigs at slaughtering in 103 kg live weight is highly dependent on sex. The barrows of the 4 breeds had a higher growth performance compared to the sows.

— The number of fattening days was also highly influenced by the sex of animals (difference being 4–7 days). Similarly to the age of slaughtering, the barrows were superior to sows.

— The average of net weight gain* are shown in the third column of the Tables 1 and 2. It may be seen than the net weight gain is also highly influenced by the sex. Comparing the sexes within breeds, the barrows were superior to sows by 10–18 grams per day.

— The sex had a higher influence than did the breed on the daily weight gain during the fattening period (gross weight gain).** The differences between the averages of breeds amounted to 20–45 g per day, and between the barrows and sows about 39–66 g per day. The significantly higher daily gain of barrows resulted in an advantage of about 5–7 days for the age at slaughter, compared to the performance of sows.

— The fifth column of Tables 1 and 2 represents the feed consumption per kg of weight gain. The determination of these values was made possible by the individual allocation of the animals. No differences were found between the sows and barrows for feed conversion efficiency, when nourished with the same nutrient content and the same composition of the ratio.

$$\text{* Net body weight gain} = \frac{\text{carcass weight}}{\text{life days}}$$

$$\text{** Brutto body weight gain} = \frac{\text{body weight gain during the fattening***}}{\text{number of fattening days}}$$

*** Finishing weight — initial weight

This indicates that the sows produce 1 kg weight gain by consuming the same amount of food as do the barrows. With respect to the fact that the barrows produce the same live weight (on average 73 kg between 30–103 kg)

Table 1

Mean values of traits related to body weight gain and feed conversion efficiency as affected by sex in Hungarian Large White and Estonian pigs

Breed	Traits	Age at slaughter (days)	Number of fattening days (days)	Average body weight gain/day calculated to warm carcass weight (net weight gain) (g)	Average body weight gain/fattening period (gross weight gain) (g)	Feed conversion per kg weight gain (kg)
Hungarian Large White						
Average	(n = 1005)	183.5^{bbb}	91.0^{bbb}	435.5^{bbb}	817.0^{bbb}	3.10
Barrows	(n = 487)	180.0***	87.7***	444.5***	850.0***	3.11
Sows	(n = 518)	187.0	94.4	426.6	784.0	3.08
Estonian						
Average	(n = 367)	175.1	87.2	455.1	853.5	3.09
Barrows	(n = 163)	172.6***	83.8***	462.7*	883.8***	3.11
Sows	(n = 204)	178.4	90.5	447.6	823.1	3.08

Legends:

* ($P \leq 5\%$)
** ($P \leq 1\%$)
*** ($P \leq 0.1\%$) within breeds and between sexes

^{b} ($P \leq 5\%$)
^{bb} ($P \leq 1\%$)
^{bbb} ($P \leq 0.1\%$) between breeds

Table 2

Mean values of traits measured regarding body weight and feed conversion efficiency as affected by sex in Swedish Landrace and GDR-Landrace pigs

Breed	Traits	Age at slaughter (days)	Number of fattening days (days)	Average body weight gain/day calculated to warm carcass weight (net weight gain) (g)	Average body weight gain/fattening period (gross weight gain) (g)	Feed conversion per kg weight (kg)
Swedish Landrace						
Average	(n = 306)	182.2^{bbb}	92.1	427.9^{bbb}	807.7^{bbb}	2.95
Barrows	(n = 145)	179.0***	90.0***	433.2**	827.1***	2.97
Sows	(n = 161)	184.7	94.3	422.5	788.3	2.94
GDR-Landrace						
Average	(n = 373)	177.4	90.0	453.6	829.5	2.96
Barrows	(n = 188)	174.4***	86.9**	461.0*	861.0**	2.96
Sows	(n = 185)	180.3	93.2	446.2	798.5	2.96

Legends: see Table 1.

Table 3

Mean values of some carcass traits as affected by sex in Large White breeds

Breeds	Traits	Shoulder, mm	Fat thickness midback, mm	Loin, mm	Ratio of fat, %	Ratio of valuable cuts, %	Weight of valuable cuts, left side, kg	Loin eye area, cm²	Carcass length, cm
Hungarian Large White									
Average	(*n* = 1005)	43.2	24.0	27.0	35.3^{bb}	42.4^{b}	16.6	35.0^{bbb}	98.3^{bbb}
Barrows	(*n* = 487)	44.6***	25.2***	28.8***	36.3***	41.5***	16.2***	33.4***	98.0*
Sows	(*n* = 518)	41.8	22.7	25.3	34.4	43.3	16.9	36.4	98.6
Estonian									
Average	(*n* = 367)	42.9	24.4	26.8	36.9	41.8	16.4	36.4	97.5
Barrows	(*n* = 163)	44.4***	25.7***	28.2***	37.7***	41.1***	16.1***	35.1***	97.3
Sows	(*n* = 204)	41.5	23.2	25.5	36.1	42.5	16.6	37.6	97.7

Legends: see Table 1.

Table 4

Mean values of some carcass traits as affected by sex in the Landrace breeds

Breeds	Traits	Shoulder, cm	Fat thickness midback, cm	Loin, cm	Ratio of fat, %	Ratio of valuable cuts, %	Weight of valuable cuts, left side, kg	Loin eye area, cm²	Carcass length, cm
Swedish Landrace									
Average	(*n* = 306)	35.8^{bbb}	19.4^{bbb}	19.0^{bbb}	32.4^{bb}	44.7	17.0^{b}	36.8^{bbb}	100.2^{bbb}
Barrows	(*n* = 145)	37.0***	20.4***	20.2***	32.8*	44.1***	16.8***	35.3***	100.0
Sows	(*n* = 161)	37.0	18.5	17.8	32.0	45.3	17.3	38.3	100.3
GDR-Landrace									
Average	(*n* = 373)	39.2	24.1	24.0	32.8	44.7	17.6	42.3	98.3
Barrows	(*n* = 188)	39.5	25.2***	25.2***	33.7***	43.7***	17.2***	40.6***	98.1
Sows	(*n* = 185)	38.9	23.0	22.7	31.9	45.6	18.0	44.1	98.5

Legends: see Table 1.

with the same feed conversion but about 5–7 days earlier than the sows, it is clear that the sows have a lower daily feed consumption during the fattening period compared to the barrows. Consequently, the higher daily gain of barrows during the fattening period (gross and net gain) resulted in their higher daily feed consumption (better appetite).

The averages of breeds for some important traits determining the slaughter value and the averages of barrows and sows within breed as well, are summarized in Tables 3 and 4. It appeared that:

— The fat thickness measurements are characteristic for the breed, and these are also influenced by sex. The fat thickness was higher for the barrows at the 3 locations by about 2–3 mm.
— The amount and ratio of fat is highly influenced by sex. The difference amounted to 0.5–1.5 kg of fat (carcass about 0.8–1.9 kg for the barrows).
— Considering the amount and ratio of the valuable cuts shown in Tables 3 and 4, it may be stated that for these traits also the sows were superior to the barrows. The ham and loin — the most important and heaviest valuable cuts —, were tendentiously more favourable in the sows. The loin eye area of the sows was larger in all investigated breeds (by about 3.0–3.5 cm^2) compared to the barrows.
— Considerable sex differences could be found for the superiority of carcass length in the sows, by about 5 mm compared to the barrows, in the four investigated breeds.

Influence of sex on the progeny test results

Because of the performance differences between sexes it is justified to question how the estimation of breeding value of the parents is influenced by the pooled results of progeny groups of both sexes, by using the progeny test. To what extent is the determination of the real breeding value of parents biased by the fact — in any way — the ratio of sexes in the progeny group was not equal? According to *the Hungarian Standard for Pig Progeny Test* (MSZ 6805) the breeding value of boars should be determined on the basis of pooled data from 10 or 12 progenies* with a sex ratio of 50–50% (Barrow: sow). The progeny test of breeding sows is carried out on only two progenies, i.e. one sow and one barrow.

When carrying out the examinations, it may happen that the ratio of sexes (50–50%) changes because of the possible losses (diseases, transport losses, etc.) in the progeny group. For the modification of the index-value, because of the reasons mentioned above, a model calculation was carried out.

* Carrying out the progeny test of boars 4–4 individuals of 3 non-related litters or 2–2 individuals of 5 non-related litter should be evaluated in central test stations.

Table 5

Progeny test index scores of boars depending on the sex ratio of the progenies

Breed	Sex of the progenies				
	100% barrows	100% sows	50 : 50%	67 : 33%	33 : 67%
			barrows and sows		
Hungarian Large White	100.4	103.0	101.6	101.2	102.1
Estonian	101.8	103.7	102.7	102.4	103.1
Swedish Landrace	103.7	105.4	104.5	104.2	104.8
GDR-Landrace	107.7	110.3	109.0	108.6	109.5

For this purpose, we used the data representing the averages of the examined population. Based on *the Hungarian Standard No. 6805*, the index-values* of the progeny groups from various boars were calculated — substituting the averages of breeds and sexes — by changing the sex ratio of progenies in the examined 4 breeds.

Some of these variations (50 : 50%, 67 : 33%, 100%) are shown in the Table 5. It may be seen that the differences from the deviations of sex ratio in the progeny groups are well compensated by the progeny test index.

In extreme cases, i.e. by qualifying a boar based only on the performances of barrow progenies, not more than 2 index scores, and for *the Hungarian Large White*, 3 index scores, could be stated. A small disparity in the sex ratio of 50 : 50% as ruled by *the Hungarian Standard* (for instance, dropping out of a sow or barrow from the progeny group) causes only a decimal change in the progeny test index value of the boar. With respect to the fact that the index value should be given in a whole number, the decimal changes caused by sex disparities undeservedly modify either positively or negatively the breeding value of a boar, because of the "rounding up" procedure.

All these call attention to the fact that the modification of sex ratio, and the evaluation of the results of progeny groups by changing the sex ratio of 50 : 50%, cannot be admitted. No allowances should be made for the progeny test of sows because of the small number of progenies (1 sow and 1 barrow).

* Based on the Hungarian Standard No. 6805–81 the index-point values (scores) of progeny test for the parents are calculated by the formula as follows:

$$I_{ITV} = 100 + 0.2\,(s-\bar{s}) + 0.02\,(\bar{t}-t) + (\bar{f}-f) + 2\,(\bar{h}-\bar{h}) + (m-\bar{m}), \text{ where}$$

s = net body weight gain of progenies per lifeday (g)
t = average feed conversion efficiency of progenies during test (g)
f = average fat percentage of the progenies (%)
h = average valuable cuts percentage of progenies (%)
m = average meat quality scores of progenies
$\bar{s}, \bar{t}, \bar{f}, \bar{h}, \bar{m}$ = corrected national breed averages of the parameters for the last two years. The index value should be given by rounding up the value to a whole number.

It was convincingly proved by the results of our investigations that there are differences between the important parameters of female and castrated pigs. By changing the sex ratio of 50 : 50% in the progeny groups and this seldom occurs in the practice, no basic differences appear in the index value of the boar. It may be concluded that further investigations are needed to elaborate the method of qualification (progeny test) based on the progeny tests with only males or only females. (Such investigations are soon in progress.)

Summary

Investigations were carried out on 2051 pigs to determine the differences between the performances of sows and barrows using an *ad libitum* feeding system, and slaughtering the animals at the live weight of 103 ± 1 kg, and their influences on the progeny test results as well. The distribution of the 4 purebred population was as follows. *The Hungarian Large White*, 1005 pigs; the *Estonian*, 367 pigs; the *Swedish Landrace*, 306 pigs; and the *German Landrace* (GDR), 373 pigs. The experiments were carried out in performance test stations, with an initial weight of 30 kg. The fattening and slaughtering were carried out according to the *Hungarian Standard No. 6805*, under standardized conditions. Based on the evaluation of the data it could be stated that.

(1) The growth performance of pigs is significantly influenced by sex, and the live weight gain/fattening days was higher for barrows.

(2) There were no differences between barrows and sows for the feed conversion efficiency.

(3) The barrows had a higher fat thickness (2–3 mm/location) and a higher fat content (0.8–1.9%) than the sows.

(4) With respect to the valuable cuts, the castrates were at a disadvantage of 1.2–1.8%, compared to the sows.

(5) The progeny test results are influenced by the sex differences between the parameters when the sex ratio of the progeny group differed from the Hungarian Standard, i.e. from the ratio of 50 : 50%. These circumstances, the incidence of which may not be excluded under practical conditions of the progeny test, could be compensated by the correction of progeny test results to a sex ratio of 50 : 50%.

(6) The possible modifications caused by the sex differences in the progeny test of parents (mainly boars) make it necessary to elaborate methods for the progeny test, based on progeny groups of the same sex.

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Acta Agronomica Hungarica, 37 (1–2), pp. 101–109 (1988)

Animal breeding

REPLACEMENT OF EXTRACTED SOYA PROTEIN BY VARIOUS SWEET LUPIN SPECIES IN PIG FEED

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(Received: 8 May 1985)

In N-metabolism test (30–50 kg) and fattening experiments (30–100 kg) with pigs 30% and 50% of soya protein was replaced by the yellow-flowered Borluta and the white-flowered Nyírségi sweet lupin varieties, respectively, in a feed mixture based on cereals.

In the N-metabolism test the 30% replacement of soya protein by Borluta and Nyírségi lupins resulted in a daily N-retention of 17.40 and 19.02 g, respectively; while with the 50% replacement the daily N-retention was 18.70 and 20.96 g respectively, in the above order.

In the fattening experiments the daily body weight increase achieved was 588 g with the variety Nyírségi and 549 g with the Borluta.

The feed conversion was 3.52 kg with the variety Nyírségi and 3.92 kg with the Borluta; that is, the former proved better than the latter in every respect. However, in the fattening experiments the results of the control (soya) group (daily body weight increase: 676 g, feed conversion: 3.32 kg) were significantly better ($P < 0.01$) than those of the groups given experimental feed.

Keywords: *Lupinus* sp., fattening value, cereal feed mixture.

Introduction

The seed of lupine species (*Lupinus* sp. L.) can be taken into account as an alternative source of protein in the feed of monogastric animals. There are reports on the results of experiments in which the varieties were found to have different degrees of antinutritive effect; in the course of other experiments plant breeders produced varieties free of alkaloid — which is one of the causes of the antinutritive effect —, and obtained favourable results by feeding them.

Vosloo (1960), Smetana and Morris (1972), Kracht et al. (1973), Hove (1974) and Schröder and Farries (1976) describe of experiments mostly with Australian, New Zealand and GDR varieties which gave favourable results owing to their high nutritive and very low antinutritive effects.

Schulz and Petersen (1978) call attention to the fact that changes in the prices of protein feeds make it undoubtedly necessary even in the German Federal Republic to increase the production of domestic protein fodders — of lupine among others — and their use as feed.

According to Florence (1965) the body weight gain of pigs was unfavourable influenced when in the cereal base feed ratio half of the fishmeal protein was replaced by sweet lupine seed.

Taverner (1975) attributes this effect mainly to the unfavourable ratio of essential amino acids in the protein of lupine seed, to the small quantity of lysine and methionine in the first place, the latter being limiting components in cereals too. Secondly, the considerable amount of fibre (14% on an average) may also be disadvantageous. Further, the average 5% oil content of the lupine seed may increase the softness of the pig's lard. In earlier comparative examinations concerning lupine varieties (Szelényi-Galántai et al. 1983) we determined the nutrient content and the biological value of protein for a number of Hungarian and foreign varieties. The results revealed a close correlation ($r = 0.89$) between the methionine and cystine content and the biological value of the lupine seed protein. These correlation encouraged us to try to improve the biological value of lupine protein by methionine supplements and completion with other fodders. Experiments to this end with albino rats yielded favourable results (Szelényi-Galántai et al. 1984), namely, the lupine seed when supplemented with 0.3% dl-methionine and fed with wheat was nearly equal in biological value to the extracted soya.

While investigations have long since been carried out in Hungary (Gundel et al. 1977, Fekete et al. 1978) concerning the use of lupine seed in pig feeding, on the basis of what have been told above we felt justified in substituting partly Hungarian bred (Nyírségi sweet white) partly GDR (Borluta yellow) varieties for 30% and 50%, respectively, of extracted soya protein in the fodder mixture of young pigs. The investigations were carried out with young pigs in N-metabolism experiments on the one hand, and in group feeding experiments over a full fattening period, on the other. With the results of our experiments we wished to provide answers to the questions of

— whether soya substituted at various ratios for lupine protein caused differences in the protein metabolism and fattening performance of young pigs, on the one hand, and
— whether these examinations would point out any difference between the two varieties, on the other.

Material and methods

The pig feeding experiments were conducted with Borluta yellow *(L. luteus)* and Nyírségi white *(L. albus)* lupines grown in 1983 at the same site. The nutrient content of the experimental fodders was determined according to standard MSZ No. 6830–79. The amino acid composition was established with a Biocal-200 type automatic amino acid analyser.

The total alkaloid content was indicated on the basis of standard MSZ No. 08-1362–80 (Table 1).

The N-metabolism tests were performed with large white barrows of 30–50 kg body weight. Each experimental feed was examined with 4 animals of the same age and body

Table 1

Nutrient content of seed in various lupine varieties

	Borluta yellow lupine (*Lupinus lutens*)	Nyírségi white lupine (*Lupinus albus*)
Dry matter content	86.0	86.0
Crude protein	42.4	36.9
Crude fat	4.0	7.2
Crude fibre	14.0	11.0
Crude ash	3.7	3.5
N-free extract	21.9	27.4
Lysine	2.32	2.23
Methionine	0.30	0.46
Cystine	0.61	0.49
Asparagic acid	4.88	4.35
Threonine	1.71	1.61
Serine	2.40	2.22
Glutamic acid	9.33	9.91
Proline	2.04	2.35
Glycine	1.16	1.00
Alanine	1.31	0.96
Valine	1.63	1.54
Isoleucine	2.34	2.04
Leucine	3.70	3.69
Tyrosine	1.57	1.62
Phenylalanine	2.31	4.35
Mistidine	1.09	0.98
Arginine	4.25	4.35
Total alkaloids	0.11	0.09

Table 2

Feeding pattern in the N-metabolism test

I. N-metabolism test

Protein source distribution in

Extractum soya	Borluta yellow sweet lupine	Extractum soya +	Borluta yellow sweet lupine	Extractum soya +	Borluta yellow sweet lupine
100%	0%	70%	30%	50%	50%

II. N-metabolism test

Protein source distribution in

Extractum soya	Borluta yellow sweet lupine	Extractum soya +	Borluta yellow sweet lupine	Extractum soya +	Borluta yellow sweet lupine
100%	0%	70%	30%	50%	50%

weight in a 5-day experimental period after 9 days of preliminary feeding. The experimental feeding followed the pattern seen in Table 2. Each group of 4 pigs consumed first the basic soya feed, then a fodder mixture combined with increasing proportions of Borluta (experiment series I) and Nyírségi (experiment series II) sweet lupine, respectively.

The body weight of the animals was taken on the first and last day of the experimental period. Further, the quantity of N consumed in the feed and excreted in the faeces and urine was measured every day in order to establish the N-balance. (N determination

Table 3

Percentage composition and nutrient content of fodder mixtures used in N-metabolism tests with pigs

	Group				
	1	2	3	4	5
Maize	43.90	41.00	40.00	41.00	40.00
Wheat	41.00	43.85	44.35	43.35	43.85
Extr. soya	13.00	9.00	9.00	6.50	6.50
Borluta yellow lupine	—	4.00	—	7.00	—
Nyírségi white lupine	—	—	4.50	—	7.50
l-lysine	0.10	0.15	0.15	0.15	0.15
dl-methionine	0.10	0.10	0.10	0.10	0.10
Cattle-salt	0.40	0.40	0.40	0.40	0.40
Feed line	0.50	0.50	0.50	0.50	0.50
647 premix (Biogal)	1.00	1.00	1.00	1.00	1.00
Crude protein content	15.8	15.7	15.5	15.8	15.4
Digestible crude protein content	12.9	13.2	13.3	13.3	13.1
Starch value, g/kg	740	739	740	739	740
DE, MJ/kg	14.7	14.5	14.5	14.5	14.4
Methionine content	0.32	0.34	0.34	0.32	0.33
Methionine + cystine content	0.56	0.55	0.57	0.54	0.55
Lysine content	0.74	0.75	0.78	0.74	0.77

Table 4

Nutrient content of feed used in the group fattening experiment

	Group		
	1	2	3
I. Fattening phase			
Crude protein, %	15.6	15.3	15.6
Starch value, g/kg	745	735	734
DE, MJ/kg	14.5	14.4	14.4
Lysine, %	0.76	0.72	0.71
Methionine, %	0.34	0.33	0.32
Methionine + cystine, %	0.57	0.54	0.53
Price of 100 kg fodder mixture, Ft	632.59	608.97	606.45
II. Fattening phase			
Crude protein, %	13.3	13.8	14.1
Starch value, g/kg	741	737	737
DE, MJ/kg	14.4	14.3	14.4
Lysine, %	0.56	0.60	0.60
Methionine, %	0.31	0.31	0.30
Methionine + cystine, %	0.51	0.51	0.50
Price of 100 kg fodder mixture, Ft	552.92	552.16	548.87

with *Kjeldahl*'s method.) From these data we could establish the apparent digestibility of protein and the productive conversion of N. (Productive N utilization = N-balance/consumed quantity of N.)

In the fodder mixture used for the N-metabolism test the extracted soya protein was replaced by Nyírségi and Borluta lupines to 30% and 50%, respectively. In the fodder mixtures the crude protein content and starch value and digestible energy content, respectively, were practically the same. With 0.1 and 0.15% l-lysine, respectively, and 0.1% dl-methionine supplemented we established that the feed rations covered the pigs' requirements of these amino-acids. The quantities of the essential amino acids mentioned were also the same in all fodder mixtures (Table 3).

The group fattening experiment was carried out in the Mezőfalva Agricultural Combinate with 20 large white pigs of mixed sex (30–100 kg in body weight) per group.

In the group fattening experiment, fattening was divided in two phases. In phase I, the body weight of the animals was 30–60 kg; in phase II, 60–100 kg. The difference between the diets of the two phase was that as regards composition and nutrient content, the feed given in phase I totally agreed with those feeds of the N-metabolism test in which 50% of the soya protein was replaced by the Borluta and Nyírségi lupine varieties (Table 3; groups 4 and 5). On phase II, on the other hand, the average crude protein content of the fodder mixtures was 13.5%, as we reduced the proportion of soya from 6% to 3% while leaving the percentage proportion of lupine unchanged. This reduction of the proportion of soya was accompanied by a decrease in the quantity of lysine in the fodder mixture of phase II (Table 4.)

Results

Table 1 gives the crude nutrient, amino acid and total alkaloid content for the sweet lupine varieties Borluta and Nyírségi. The crude protein content is 42.4% in Borluta but only 36.9% in the variety Nyírségi. These values agree with those published by Bódis et al. (1983) for the same varieties. There is a considerable difference between the two varieties in crude fat content (4.0% and 7.2%, respectively) and crude fibre content (14.0% and 11.0%, respectively). The total amount of sulphur-containing amino acids and the lysine content are also equal in the two varieties. The difference in total alkaloid content — 0.11% and 0.09% respectively — between the two varieties in minimal. The fodder mixtures prepared with the two lupine varieties mentioned and the major characteristics of their nutrient content are shown in Table 3.

N-metabolism tests

In the N-metabolism test I young pigs of 32 kg average weight consumed first a feed prepared with soya (group 1); then a fodder mixture with Borluta lupine substituted for 30% of soya protein (group 2) was given to animals of 40 kg body weight, and with Borluta substituted for 50% of soya protein to animals 48 kg in body weight.

The N-metabolism test II was carried out in a similar way with the variety Nyírségi.

As seen in Table 5 the body weight of young pigs when consuming the basic soya diet was exactly the same in both N-metabolism tests. Differences appeared however, in the N-intake of the animals, due to a lower feed consumption. The quantity of N excreted in the urine and faeces was, however,

Table 5

Changes in N-metabolism and protein utilization

<table>
<tr><th rowspan="3">Parameters of examination</th><th colspan="6">Distribution of protein source</th></tr>
<tr><th>Extractum soya</th><th>Borluta yel-low-sweet lupine</th><th>Extractum soya</th><th>+ Borluta yel-low sweet lupine</th><th>Extractum soya</th><th>+ Borluta yel-low sweet lupine</th></tr>
<tr><th>100%</th><th>—</th><th>70%</th><th>30%</th><th>50%</th><th>50%</th></tr>
<tr><td colspan="7">I. N-metabolism test</td></tr>
<tr><td>$\bar{x}$ body weight, kg</td><td colspan="2">32</td><td colspan="2">40</td><td colspan="2">48</td></tr>
<tr><td>Daily $\bar{x}$ feed uptake, g</td><td colspan="2">1555</td><td colspan="2">1720</td><td colspan="2">1800</td></tr>
<tr><td>Daily x N-balance, g</td><td colspan="2">15.91</td><td colspan="2">17.40</td><td colspan="2">18.70</td></tr>
<tr><td>N-balance g/live weight$^{0.67}$</td><td colspan="2">1.56</td><td colspan="2">1.47</td><td colspan="2">1.40</td></tr>
<tr><td>N-digestibility, %</td><td colspan="2">78.8</td><td colspan="2">84.3</td><td colspan="2">84.0</td></tr>
<tr><td>Productive N-utilization, %</td><td colspan="2">42.5</td><td colspan="2">40.2</td><td colspan="2">43.3</td></tr>
<tr><th rowspan="3">Parameter of examination</th><th colspan="6">Distribution of protein source</th></tr>
<tr><th>Extractum soya</th><th>Nyírségi white sweet lupine</th><th>Extractum soya</th><th>+ Nyírségi white sweet lupine</th><th>Extractum soya</th><th>+ Nyírségi white sweet lnpiue</th></tr>
<tr><th>100%</th><th>–</th><th>70%</th><th>30%</th><th>50%</th><th>50%</th></tr>
<tr><td colspan="7">II. N-metabolism test</td></tr>
<tr><td>$\bar{x}$ body weight, kg</td><td colspan="2">32</td><td colspan="2">41</td><td colspan="2">50</td></tr>
<tr><td>Daily $\bar{x}$ feed uptake, g</td><td colspan="2">1400</td><td colspan="2">1700</td><td colspan="2">1900</td></tr>
<tr><td>Daily $\bar{x}$ N-balance, g</td><td colspan="2">16.13</td><td colspan="2">19.01</td><td colspan="2">20.96</td></tr>
<tr><td>N-balance g/live weight$^{0.67}$</td><td colspan="2">1.58</td><td colspan="2">1.58</td><td colspan="2">1.52</td></tr>
<tr><td>N-digestibility, %</td><td colspan="2">84.0</td><td colspan="2">85.8</td><td colspan="2">85.4</td></tr>
<tr><td>Productive N-utilization, %</td><td colspan="2">49.7</td><td colspan="2">47.4</td><td colspan="2">47.2</td></tr>
</table>

substantially more with those animals whose N-uptake was higher, with the consequence that the N-balance showed hardly any difference (15.91 and 16.13 g, respectively). The animals that took up more N excreted more N in the faeces, consequently the apparent N-digestibility was only 78.8%; while in the N-metabolism test II, they reached 84%. This difference is seen as well in the productive N-conversion. Namely, when the N-uptake was higher the productive N-conversion was only 42.5%, while with a lower N-uptake, it rose to 49.7%.

When 30% of the soya protein was replaced by lupine the N-balance was 17.40 g with Borluta and 19.01 g with Nyírségi consumed. The difference in N-digestibility was small (84.3% and 85.8%, respectively). The productive N-utilization was, however, 47.7% with the variety Nyírségi and 40.2% with Borluta.

When 50% of the soya protein was replaced by lupine the N-metabolism was invariably more favourable with the variety Nyírségi, the daily N-balance being 18.70 g with Borluta and 20.96 g with Nyírségi consumed by the animals. The value of N-digestibility was equal to that in the former N-metabolism test.

The productive N-utilization slightly improved (43.3%) with Borluta and did not change with the variety Nyírségi.

Since the N-metabolism tests could not be carried out with animals of totally equal body weight, the daily N-balance of the soya group fell behind that of the groups given lupine. For this very reason we give the N-balance values for metabolic weight (live weight$^{0.67}$) as well. Accordingly, in the N-metabolism test I it is 1.56 for the soya group, then 1.47 and 1.40 g/live weight$^{0.67}$ with increasing proportions of Borluta substituted for soya protein. In the N-metabolism test II, with the variety Nyírségi substituted for soya protein the corresponding values are 1.58, 1.58 and 1.52 g/live weight$^{0.67}$

These values indicate that soya as an ideal source of protein gives the most favourable N-retention. With a 30% replacement by the lupine variety Nyírségi the result of the soya group can be maintained, but when substituting the variety Borluta for soya the N-balance will slightly decline.

Fattening experiments

The major characteristics of the group fattening experiment are summarized in Table 6. Since the results of the N-metabolism test showed that even a 50% replacement of the soya protein by lupine did not prove unfavourable for the balance, digestibility and utilization of N, we used this ratio in

Table 6

Major data of the group fattening experiment

	Group		
	1 (control)	2	3
Initial body weight, kg	31	31	31
Body weight at the end of fattening phase I, kg	66	60	62
Body weight at the end of fattening phase II, kg	100	87	91
Number of fattening days	102	102	102
Daily body weight gain in phase I (31–66 kg), g	648	537	574
Daily body weight gain in phase II (66–100 kg), g	708	562	604
Daily body weight gain during the whole fattening period (31–100 kg), g	676	549	588
Fodder mixture used for 1 kg body weight gain, kg/kg	3.32	3.92	3.52
Price of fodder mixture used for 1 kg body weight gain, Ft	19.56	22.65	20.25

phase I of the fattening experiment, that is within 31 and 30 kg body weight of animals. In phase II, in accordance with the practice of large farms, we used a fodder mixture containing 13.4% crude protein in both the control (group 1) and the two experimental groups. The daily weight gain of pigs was 676 g in the control and 549 and 588 g in the groups given Borluta and Nyírségi lupine, respectively, in the fed. The amount of fodder mixture used up for 1 kg body weight gain followed the same tendency: it was 3.32 kg in group 1; 3.92 kg in group 2; and 3.52 kg in group 3. Calculated at 1984 prices the cost of the fodder mixture consumed for 1 kg body weight gain was 19.56 Ft in group 1, 22.65 Ft in group 2, and 20.25 Ft in group 3.

Discussion

According to the results of N-metabolism tests, 50% of the soya protein can be replaced by either of the two lupine varieties, but with the variety Nyírségi better N-retention and productive conversion can be achieved than the Borluta. The differences are not, however, significant.

In the group-fattening experiment, the results of the control group (group 1) were significantly better ($P < 0.001$) than those of the groups given lupine in the feed. A comparison of the two lupine-groups reveals that the daily weight gain of animals consuming the variety Nyírségi was 7% and their feed conversion 10% better than in the group given the variety Borluta. The results of the experimental groups were at the same time worse than those of the control. This confirms our earlier statement (Szelényi-Galántai et al. 1984) that apart from a deficiency of sulphur-containing amino acids and lysine there are other antinutritive factors in the lupine which are responsible for the fact that fodder mixtures prepared with lupine varieties does not reach the efficiency of those combined with good quality soya. This antinutritive action is related to the alkaloid content of the lupine, since the total alkaloid content of the lupines used in the experiment did not exceed the prescribed limit (Takarmánykódex 1984), and its proportion in the fodder mixture did not reach 0.03%, a quantity considered acceptable by Ruiz et al. (1977).

The lysine demand of pigs was sufficed by 0.1% lysine supplemented in the soya group. The lysine supplement given in the lupine groups was 0.15% and although this quantity of lysine was equal to that supplied in the control it seems not to have fully compensated for the unfavourable nutritive effect of the lupine. In spite of this, according to our fattening results 7.5% of the Nyírségi white lupine variety in the fodder mixture kept the feed conversion of the pigs on a favourable level, so this Hungarian variety should be given preference when preparing concentrates for pigs.

Yet, it should be noted that the favourable results of the N-metabolism tests were not fully confirmed by the semi-scale fattening experiments. This may also mean that in a relatively short period the lupine does not make its antinutritive effect felt to such an extent as it does in a full fattening period. On this point the experiments carried out by Jécsai et al. (1985) with white rats provide some information; namely, in a long-term experiment (60 days) they found that the lupine, even when completed by other fodders and synthetic amino acids, exercised a certain depressive effect manifested in lower body weight gain. This depressive effect involved an increase in the urea content of blood and changes in the amino acid composition of the liver. All this means that when in a fodder mixture based on cereal soya is the only source of protein, then only 30% of this protein should be replaced by sweet lupine, and in the second phase of fattening (between 60 and 100 kg body weight) the proportion of soya should not be further decreased. This view was supported by the fattening experiments of Gundel et al. (1977) and Fekete et al. (1978) who suggested to applying other protein carriers beside cereals, when substituting lupine for soya protein.

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Acta Agronomica Hungarica, 37 (1–2), pp. 111–121 (1988)

SOME CONCLUSIONS CONCERNING THE LARGE-SCALE ACCELERATED LAMBING OF HUNGARIAN MERINO EWES

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(Received: 23 January 1985)

At present more than 90 per cent of the ewe stock of Hungary is made up of Merino sheep. Under Hungarian conditions large-scale sheep farming can expect reliable profits either from milking or from a more frequent lambing of ewes (Ráki and Raskó 1984, Tildi and Timkó 1982). Since most of the large sheep farms are not willing to milk, frequent lambing should be practised on a technological level able to create the production conditions of profitability.

Keywords: Merino sheeps lambing, milking, profitability.

Introduction

In the USA, the critical situation and the annually decreasing sheep stock have urged researchers to subject the methods and conditions of accelerated lambing to close scrutiny. This approach makes it possible to make sheep raising profitable again by means of more up-to-date utilization of a given stock, instead of turning to another breed. (Over the past few years the number of sheep in the USA has been on the rise again.) Several breeds and crosses have proved suitable for accelerated lambing. Grading them in the order of decreasing efficiency, the first place is taken by Dorset, followed by Dorset × Rambouillet, then Rambouillet, finally Rambouillet × Suffolk and Rambouillet × Hampshiredown (Barker and Wiggins 1964, Miller and Wiggins 1964, Copenhavar and Carter 1964, Outhouse et al. 1965). In the case of Columbia, however, a crossbreed of Merino and Longwool, accelerated lambing did not prove successful (Outhouse 1971). Lambings repeated every 7–9 months increased the previous lambing turnovers from 0.8–0.9 to 1.2–1.3 thus giving 0.3 to 0.6 extra lambs. By contrast, although forced lambings every six months, an end to the seasonal quality of lambing, the surplus lamb yield was reduced compared to the 7–9-month lambing approach and the rise in costs inherent in this method was not recovered (Carter 1968). It only proved productive when the lambs were taken away from the ewes immediately after birth and raised artificially (Walton and Robertson 1974).

Since then a number of reports have been published in Europe suggesting that certain breeds have always been subjected to accelerated lambing. On processing 680.00 lambing data for Romanov ewes monitored in the Tutaev region, Kovnerev (1969) has demonstrated that 20 to 30% of these ewes lamb twice annually. The registered ewes of the Austrian Bergschaf breed achieved an average lambing turnover of 1.36–1.42 between 1964 and 1975, with 1.97–2.24 live-born lambs (Wisheit 1976). Yet another extreme example is provided by Finnsheep ewes, kept with the rams throughout the year, which were able to lamb every 6 to 9 months (Maijala and Kangasniemi 1972). Scharfenberg (1978) kept his Landschaf ewe stock of about 2000 together with the rams, and had his lambs reared artificially, originally from the first day and later from the 8th to 10th day. About one-third of the ewes lambed only once a year, while the rest systematically lambed every 6–7 months. In France, the Ile de France breed has also proved capable of accelerated lambing (Mauleon 1979).

On the basis of experimence gained when lambing Rambouillet ewes every 8 months Outhouse (1971) came to the conclusion that selection is necessary to improve the capability for accelerated lambing. In 1969, Kovnerev reported that under appropriate conditions of raising and feeding the Romanov breed can lamb every six months. On the basis of a large number of experiments (1–2–3–5–6–7–8–13–14–15–19–23–24), numerous authorities agree with the above views (Burgkart, Kőnig, Maijala, von Scharfenbert, Wassmuth). The authors are firmly convinced that their opinion is acceptable.

Furthermore, the economic benefits of accelerated lambing, as compared with those of milking, were demonstrated at the 1974 Congress of the EAAP in Vienna by a delegate from Israel, a country which can be considered the record-holder in terms of the amount of milk per ewe (Fái 1974).

Preliminary work

Data were collected from several large sheep farms in geographically and economically diverse regions of the country, where attempts were made to successfully apply the technology of accelerated lambing in Merino ewe stocks without hormone treatment or light programmes, but exclusively through professional care and feeding, combined with up-to-date work organization and an effective final-product wages incentive.

In a breeding stock of 600 in the Transdanubian region ("November 7th" Cooperative Farm, Balatonszabadi), re-mated following weaning in the 6th–8th week, the average lambing turnover in six consecutive years (1974 to 1979) was 1.23 and the live lamb yield 1.91. These results were achieved under adverse conditions in the sense that mating delayed on occasion in order to await more favourable marketing dates. The 150% average increase rate was practically unaffected by the number of lambings: the lambing interval of twin-bearing ewes exceeded the average lambing interval by a mere 3 days ($\bar{x} = 286$ day, $\bar{x} = 289$ days), and this deviation did not prove to be statistically significant (Veress 1981).

On a sheep farm on the Great Hungarian Plain ("May 1st" Cooperative Farm, Karcag) a large area of pasture was subrilled, limed and covered with topsoil. It has since been grazed alternately by means of an electrical fence. The ewes are allowed to graze, drink and rest in the pens or in the open air *ad libitum* any time of the day. After the lambs are weaned in the 5th–7th week, the rams are kept with the ewes. As indicated by the annual averages from 1978 to 1982, the lambing turnover was 1.34 and the rate of productivity per ewe 1.52 (Table 1). The prolificacy indexes of the ewes raised under these conditions of grazing and involved in the breeding programme at an earlier age (lambing for the first time at the age of 15–18 months) turned out to be

Table 1

Accelerated lambing results for the rambouillet sheep of the "May 1st" Cooperative farm, Karcag

Year	Eve stock	Greasy wool		Lambs born in the				Lambing rate	Pro-lificacy	Lambs per ewe	
				1st	2nd	3rd	4th				
		kg	Ft/kg	quarter of the year						born	weaned
1978	825	5.02	101.7	28	676	63	205	1.075	109.6	1.178	1.06
1979	2030	5.42	103.8	1667	196	428	724	1.280	116.0	1.485	1.08
1980	1983	5.50	104.3	864	699	641	804	1.285	118.0	1.517	1.57
1981	2071	4.97	111.4	390	1514	504	510	1.214	116.0	1.408	1.18
1982	2132	4.78	110.2	1740	246	678	1202	1.450	125.0	1.813	1.71
$\bar{x}$	1808	5.14	106.3	34%	24%	17%	25%	1.342	118.4	1.524	1.36

Table 2

Trend in yield and prolificacy indexes for milked and dired up rambouillet ewes
(Végh 1977)

Specification	Time of lambing			
	February–March		June–July	
	Dried up	Milked	Dried up	Milked
Ewe stock (No.)	745	632	546	601
Rate of oestrus (%)	57	50	85	82
Conception rate (%)	40	35*	57	55
Prolificacy rate (%)	108	107	109	111
Litter size per ewe (No.)	0.432	0.354	0.621	0.610
Milk produced (litres)	—	35	—	38

* $P < 5\%$

Table 3

Productivity indexes of a Merino ewe stock subjected to accelerated (every 4 months) mating and lambing

Specification	1967	1970	1971	1972	1973
Average ewe stock (No.)	8213	9758	9751	9148	8652
Lambing rate (%)	1.11	1.20	1.09	1.05	1.23
Lambs per ewe (No.)	1.21	1.29	1.20	1.30	1.39
Milk produced/ewe (litres)	28.4	23.9	24.2	31.0	37.1

Specification	Lambing time					
	March–April		July–August		November–December	
	1969–72	1973	1969–72	1973	1969–72	1973
Ewes which conceived (No.)	39 459	5966	15 436	5264	30 651	7685
Rate of oestrus (%)	86.9	95.7	48.1	59.4	73.7	73.7
Conception rate (%)	71.7	67.9	35.9	50.2	47.8	50.9
Prolificacy rate (%)	109.7	120.1	107.2	105.5	110.2	109.5
Lambs % of reared	95.0	94.5	95.0	98.0	95.8	94.5
Productivity* (%)	73.7	77.1	36.5	48.4	50.5	52.7

* Number of weaned lambs per 100 ewes

more favourable compared with those of traditionally raised ewes (Veress et al. 1979/b).

In the sheep flock of a state farm at Szendrő, located in a hilly area, following a 6–8-week period of suckling some of the ewes were dried up, while others continued to be milked. After weaning, both groups were tested and artificially inseminated (Table 2). Owing to the fact that the milked ewes were amply fed on rations adjusted to their production (1 kg of fodder and grazing *ad libitum*), the reduction in lamb yield proved insignificant in relation to ewes that went dry. The milk produced, however, increased the income of the sheep farm by 12–15% (Végh 1977). In the last year of observation, a mating period of 6–8 weeks was repeated three times annually after weaning in the 5th or 6th week. The restriction in the suckling period improved the number of weaned lambs per 100 inseminated ewes in all three mating seasons, while the specific milk yield also rise as a result of early weaning (Table 3). The combined utilization of accelerated lambing and milking has since been introduced and successfully applied in the "Béke" Cooperative, Hajdúböszörmény, and in the "Új Élet" Cooperative, Báránd.

The place and method of the experiment

Three flocks at a sheep enterprise in the North-Eastern part of the Hungarian Plain ("Lenin" Cooperative Farm, Csenger) are situated in building surrounded by artificially laid grass, and the conditions for winter feeding are also favourable. The ewes are mated and lambed throughout the year; therefore, the one-shepherd-per-flock system has been abandoned. The shepherds are organized in teams and their wages are determined exclusively by the final products (shorn wool, weaned lambs). One two farms, lacking suitable shepherds and foremen, only one lamb per ewe was weaned annually (Veress and Végh 1982). On the third farm, where, although the foreman was replaced several times, the shepherds did a good job, the lambing and prolificacy data from the individually recorded data cards were processed with a computer for the three years 1981 to 1983. Before breeding, the ewe stock was subjected to selection, primarily on the basis of healthy constitution, and animals with wool defects were culled. Therefore, in terms of fertility and prolificacy the stock only represented the average of the Hungarian Merino breed. During the three-year period only forced slaughter and death served as reasons for culling.

During the observation period, insemination was performed several times with transported sperm from Booroola rams which led to a fertility rate of

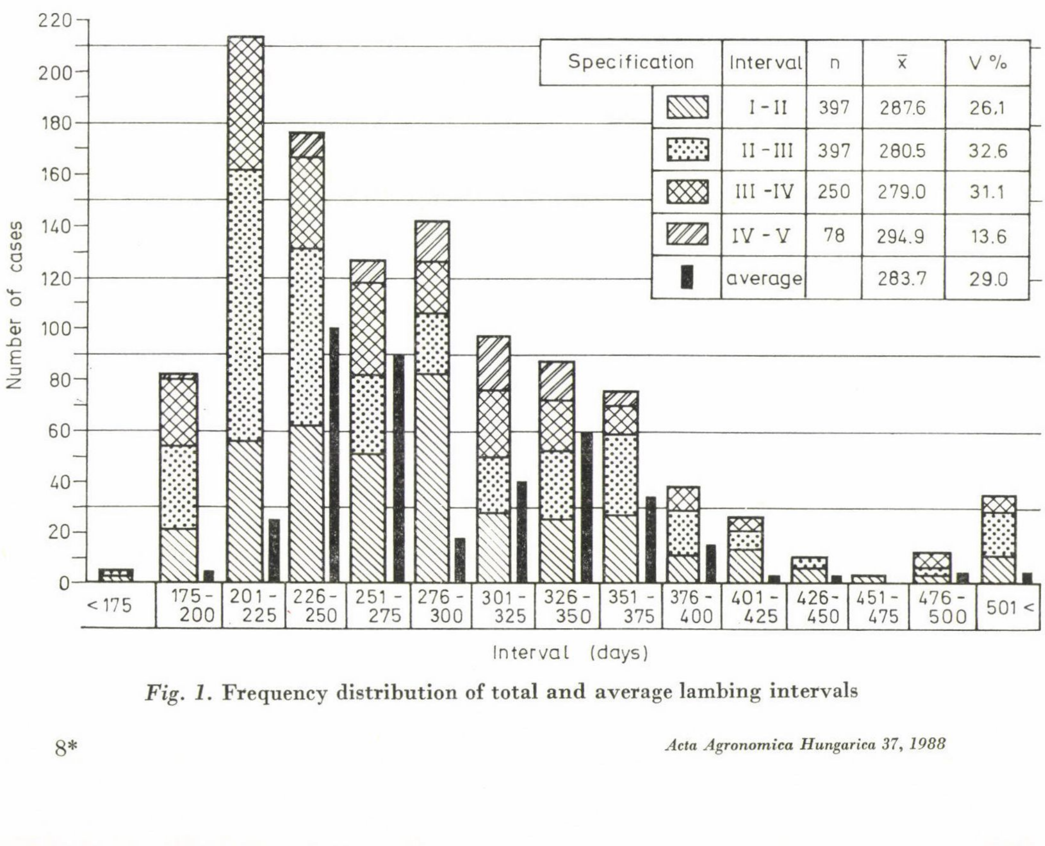

Fig. 1. Frequency distribution of total and average lambing intervals

Table 4

Prolificacy indexes of the
(n =

	Year	Jan.	Feb.	March	Apr.	May
	1981	125	58	47	57	34
	1982	39	40	17	13	33
Lambing	1983	97	52	42	18	—
	Total	261	150	106	88	67
	Percentage	17.3	10.0	7.0	5.8	4.4
	1981	15	9	8	9	7
	1982	3	2	2	8	7
Twinning	1983	17	8	4	2	—
	Total	35	19	14	19	14
	Prolificacy rats	113.4	112.6	113.2	121.6	120.8

15–30% and reduced the results in 1982 and 1983. At present insemination is performed with locally obtained sperm from Booroola rams, while ewes re-oestruating are mated with rams. Thus there can be no doubt the identification of the lambs. Since October 1983 not only the mothers of lambs weaned at a body mass of 12 kg, but also those still suckling were teased and inseminated. Between October 1983 and January 1984 large numbers of suckling ewes re-oestruated and mated while still suckling. For 172 lambings monitored between May 15 and June 30 1984 73 ewes (42%) became pregnant in December and January, i.e. during the suckling period. Presumably, therefore, their prolificacy results will exceed those in the two previous years.

Discussion

The monthly breakdown of lambings and twin lambings is presented in Table 4. In Hungary, the frequency of twin lambings is highest in the first four months of the year. In the present case, high prolificacy rates were achieved when the number of lambings was low, so that more time and attention could be devoted to caring for the animals.

Figure 1 charts the results of the total number of lambings, repeated lambings per ewe, and the required interval for repeated lambing, divided into categories, as a function of the number of lambings. It is assumed that in the case of lambing intervals exceeding a year the reasons for the failure to re-lamb must be looked for in unrecorded dead lambings, untimely foetal deaths, abortion (usually of chlamydeous origin), or barrenness of alimentary origin (poor condition, deficiency of vitamin P, perhaps of se, or A, etc.). In the case of both the total number of lambing periods and the average

Rambouillet ewes investigated
397)

June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
10	2	3	2	76	165	23	602
187	24	6	—	14	24	70	467
21	4	1	—	15	115	71	436
218	30	10	2	105	304	164	1505
14.5	2.0	0.7	0.1	7.0	20.3	10.9	100
1	—	1	2	19	32	4	107
27	10	1	—	2	4	14	80
1	—	—	—	5	8	4	49
29	10	2	2	26	44	22	236
113.3	133.3	120.0	200.0	107.7	114.4	113.4	115.7

lambing period, the percentage of ewes that showed a tendency for relambing in 10–12 months was 29%. This ratio is in agreement with the results of Scharfenberg (1978) for the Merino Landschaf breed and with the accelerated lambing results obtained for Rambouillet ewes in a breeding flock in Hajdúszoboszló (Veress 1978).

In the Merino breed, therefore, the estimated proportion of ewes unsuited for accelerated lambing is about 20–25%. At the same time, however, 54% of the population investigated consistently lambed every 6–9 months. Although for lambing periods the individual cases and the per-ewe averages reflect fairly similar results, the reproducibility of the consecutive lambing periods is slight and non-significant. This is accounted for by the fact that repeated conception is likely to be influenced by the given season, the day length and the manner of mating (hand mating with locally obtained sperm or insemination with transported sperm) to a statistically significant degree ($P < 1$–5%). Although the average interval between consecutive lambings tends to decrease, this is bound to be unreliable owing to the relatively slight differences and the considerable deviations within the groups (Table 5).

In accordance with earlier observations, even in the case of breeds showing good aseasonal oestral and conceptional qualities, the efficiency of mating can be considerably affected by the change in the amount of daylight (Veress et al. 1979/a). The time required for renewed conception in ewes undergoing oestrus for the second time in the main season is significantly longer ($P < 0.1\%$) than in the pre- or post-season, and even more so when conception occurs out of season ($P < 1\%$). The renewed conception of ewes which conceived in the main season will obviously be out of season, while those which conceived aseasonally will have their next pregnancy during the main season. The chance of repeated conception after the pre- or post-season oc-

Table 5

Correlation between the time of conception, the number of lambings, and the subsequent lambing intervals

Mating group	Lambing period	Number of cases	Lambing interval (days)		
			$\bar{x}$	s	V%
1. Main season (September 1 to November 30)	I–II	226	309	71	23.12
	II–III	100	335	82	24.68
	III–IV	38	298	25	8.62
	IV–V	52	288	43	15.07
2. Pre- or post-season (July 1 to August 31, December 1 to January 31)	I–II	125	263	75	28.52
	II–III	100	261	85	32.67
	III–IV	70	303	68	22.76
	IV–V	18	310	24	7.88
3. Out of season (February 1 to June 30)	I–II	46	238	51	21.34
	II–III	121	262	89	34.07
	III–IV	142	261	100	38.42
	IV–V	8	295	41	13.92
	Lambing period (days)				
	I–II	397	287	75	26.15
	II–III	397	280	91	32.65
	III–IV	250	279	86	31.13
	IV–V	78	294	40	13.65
Total		1122	283	82	29.00

cupies and intermediate position between the two extemities. With respect to the average repeated lambing in groups I, II and III for those conceiving for the third time, the discrepancy is even more striking ($P < 0.1\%$). As regards the three groups of ewes conceiving for the fourth time, only the average of group III shows a significant divergence from the other two groups ($P < 1\%$). With regard to the interval between the fourth and fifth lambings, there is a significant difference in favour of group I between groups I and II ($P < 5\%$) and random differences between groups I and III, while the differences in all three groups show a deviation from earlier tendencies.

The proportion of lambings in the third quarter of the year is somewhat more favourable in the Karcag stock (cf. Table 1). Yet the national situation is well reflected in the fact that the Merino breed is less likely to become pregnant between February and May. One obvious reason for this is the highly controversial practice of bringing shearing forward to March instead of the traditional May–June period, while dipping against ectoparasites is carried out 1–3 months later. Thus, oestrus is inhibited by stress effects twice during spring-time, instead of only once.

An important value parameter in the national registration and breeding system is the average daily mass gain of lambs up to the age of 120 days, which is in close genetic correlation with mature body mass. Likewise, the

Table 6

Correlation between body mass and average lambing interval

Category (kg)	n	Lambing interval (days)			Minimum	Maximum
		$\bar{x}$	s	V%		
< 32	7	276	45	16.46	223	356
33–34	10	298	90	30.18	219	516
35–36	12	284	47	16.53	225	359
37–38	30	292	73	25.16	204	489
39–40	29	299	55	18.69	236	441
41–42	91	292	62	21.24	203	510
43–44	45	289	67	23.21	210	527
45–46	59	282	52	18.42	186	391
47–48	37	278	47	17.10	207	362
49–50	37	284	44	15.56	220	381
51–52	17	312	77	24.74	198	519
53–54	12	326	72	22.17	249	487
55 <	11	294	50	17.25	230	362

highest possible body mass at the age of one is one of the criteria for grading ram hoggets marketed for breeding. As a result, in registered Merino breeding stocks the body mass of adult ewes has increased by 12 kg (30%) in 25 years (Németh et al. 1982). Therefore, examinations were made to discover what average lambing periods were associated with the various body mass categories (Table 6). The average body mass in the stocks investigated is lower ($\bar{x} = 42.83$ kg) than in the registered breeding stocks ($\bar{x} = 53$ kg). As indicated

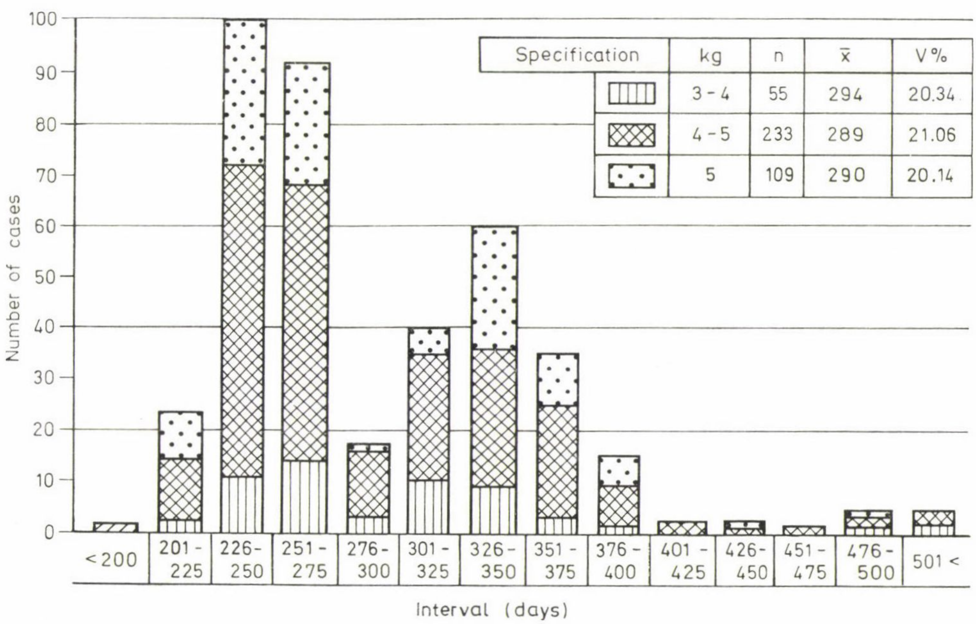

Fig. 2. Frequency distribution of average greasy wool production and lambing periods

Table 7

Correlation between twinning and lambing intervals

	n	Percentage	Average lambing interval (days)					LSD5%
			$\bar{x}$	s	V%	minimum	maximum	
No twin births	211	83.0	301	62	20.83	203	527	—
Twinning once	140	5.5	281	56	20.23	185	489	41.6*
Twinning twice	38	9.5	270	45	16.93	200	366	20.4*
Twinning three times	8	2.0	247	17	6.88	217	264	41.6*

* In relation to non-twinning ewes $P < 1\%$

by the range of values in the table, the shortest interval between lambings was obtained for the medium body mass range (41–50 kg). The difference for lower-mass groups did not prove to be statistically significant. The lower number of pregnancies for ewes in the 51–55 kg class, however, is not random ($P < 1$-5%).

Breeders of stock poultry have long been convinced that an increase in body mass contributes to a decrease in prolificacy. In pig breeding, this recognition has lately led to mounting interest in small-bodied Chinese breeds of pigs with a high rate of prolificacy. It is therefore time sheep breeders also took note of this tendency.

When classifying the investigated sheep population according to a three-year average of greasy wool production ($\bar{x} = 4.65$ kg, $s = 0.67$), it has been demonstrated that no real correlation can be established between lambing periods and the average greasy wool production (Fig. 2).

Finally, it was wished to establish whether twinning tended to affect the lambing interval (Table 7). It was found that in the group without twin lambings the mean lambing intervals were substantially longer than in the group with one, two, or three twin lambings per ewe. This discrepancy is not random and shows a decreasing tendency. An analysis of variance for ewes twinning once, twice or three times, showed no significant differences. The investigations have confirmed the opinion that the higher prolificacy and better aptitude for renewed pregnancy of ewes bearing twins justify a combined selection on the basis of these two traits for the Hungarian Merino breed (Veress 1978, Veress et al. 1979/a).

Conclusions

(1) The Hungarian Merino is capable of accelerated lambing every 7–9 months, achieving an annual lambing rate of 1.2–1.4 and a lamb yield of 1.4–1.6, provided the technology, feeding, work organization and wage conditions are satisfactory.

(2) Accelerated lambing can be combined with milking which increases the expected income.

(3) In selection breeding accelerated lambing and the tendency for twinning can be well compatible. Combined selection for both traits is both necessary and worth-while.

(4) No correlation has been found between greasy wool production and the tendency for accelerated lambing. Increasing body mass reduces the propensity for accelerated lambing.

(5) The Hungarian sheep registration standard is in urgent need to modification along the lines of up-to-date genetic principles.

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Acta Agronomica Hungarica, 37 (1–2), pp. 123–133 (1988)

THREE-TIMES-A-DAY MILKING IN HIGH PRODUCTIVITY COW STOCK

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(Received: 20 January 1986)

We indicated in our experiment that milk production adjusted for 305 days resulted in a 12.3% surplus in the overall evaluation of the thrice-daily milked group compared to that milked twice a day. This surplus depends to a considerable extent on the level of milk production. The improvement is 9.2% with cows giving steady 26–34 kg milk, and 23.8% with those adjusted to 34 kg milk or more. According to our results the positive effect of the thrice-daily milking is realized primarily in the second phase of lactation following the peak, thus improving the persistence. The results of analyses show that a decrease in the percentage of butterfat must be considered in every lactation; yet, we found a 16.8% improvement in the total butterfat production of high productivity cows. We examined the cows for feed consumption, nutrient uptake and feed conversion. In comparison to cows milked twice a day, those milked thrice showed 2.5–3.3% increase in nutrient uptake and 15% improvement in feed conversion. Three daily milkings are efficient only in those dairies where the milk production standard is 6000 kg and the operation and feeding have reached an appropriate level.

Keywords: Cows, milk production, milking frequency.

Introduction

Since Thaer (1804) stated 170 years ago that "cows are reasonably milked three times a day until they have much milk and it is worth the trouble, but when they no longer have much milk and give hardly more than (2 quarts), no benefit is derived from three daily milkings" innumerable publications and reports have appeared on the question. It must be noted that the annual milk production reckoned with was about 1200 kg at that time (Schönmuth and Lehmann 1965). However, Thaer's 19th century statements hold true even today. Moreover, the importance of this technological procedure is supposed to keep increasing. Schönmuth and Lehmann (1965) cite a number of authors who speak of a 0–25% increase in milk production as a result of changing over from twice to thrice daily milkings. In their experiment, this change resulted in the following yield increase:

Daily milk production (kg)	Increase (%)
10–15	5– 7
15–20	7–10
20–25	12–15
25–30	20–24

Apart from the authors cited the positive effect was confirmed by the results of many earlier investigations (Bogart, McKenzie and Mutto 1977, Poole 1981, Cash and Yapp 1950, Elliot 1955, Pearson, Fulton, Thompson and Smith 1979, Pelissier, Koong and Bennett 1978, Madsen 1983, Watterman, Harmon, Nemken and Langlois 1983, Wiggans and Grossman 1980, Archer 1983, Hendrian 1983), while among the Hungarian authors let us mention the following: Guba 1953, Czakó and Guba 1956, Guba and Czakó 1957, Guba and Dohy 1979, Horn 1973, Balatoni and Ketting 1981, Facsar 1979, Molnár 1981, Elek 1980, Budai and Turi 1984, Báldy 1983, Timotity 1981, Tresser 1978 and Csiffó 1978. All these describe favourable results obtained overseas from milking three times a day.

We can safely say that from a practical point of view the question of milk production is more timely than ever. To the full exploitation of genetic potentials existing in the Hungarian milking stocks thrice daily milking can undoubtedly make a great contribution. With its help milk production can be enormously increased without any increase in the investment demand and number of animals. It belongs to those technological elements through which — with due care — the results becomes immediate.

Although the technical books and the publications cited provide useful advice as to the methods of changing over to the new practice, a number of questions still remain open. With our experiments we therefore wished to contribute answers to the following:

— Is it worth milking each cow of the stock three times a day, and if not, how are we to place the animals in groups of twice- and three-times milked cows, respectively?
— What should be the production level determining the classification?
— Can the favourable effect of three-times milking on the volume of milk production be expected in each lactation?
— In which phase of lactation will the favourable effect show?

Material and methods

The investigations covered two groups of freshly miking cows placed in the group of twice ($n = 84$) or thrice ($n = 89$) milked cows according to the result of the first milk record post partum. The distribution of cows according to genotype was:

	Frequency of milking	
	2×	3×
European lowland × Holstein		
F_1 cows	13 cows	12 cows
R_1 cows	19 cows	27 cows
R_2 cows	12 cows	12 cows
R_3 cows	6 cows	3 cows
Pure-bred Holstein cows	34 cows	35 cows

Distribution of animals according to the number of lactation:

Lactation	Frequency of milking 2×	3×
1	25	20
2	23	26
3	24	24
4	6	12
5	5	5
6	1	2

The milk production of the cows was assessed by Wood's function on the basis of monthly official milk records (Szücs, Mócsi, Szőllősi and Ács 1982), and the milk samples taken were analysed for butterfat and milk protein content in the Milk Laboratory of the ÁTK. The amount of feed consumed was weighed by day and group. Milking was carried out in two shifts. The thrice milked cows were milked first at 5 a.m., then at the end of the first shift at 11 a.m., and at the end of the afternoon shift at 7 p.m. The milking intervals were 10, 6 and 8 hour.

Results

(1) According to the unanimous opinion of the relevant literature in response to thrice-daily milking the milk production of cows increases. Madsen (1983) considers the rate of increase to be about 20%, and offers the following explanations: (1) the pressure in the udder decreases, (2) the concentration of milk components that hinder the lactiferous cells in functioning decreases, and (3) three daily milkings stimulate the activity of certain hormones, which increases the milk production. Horn (1973) explains the increasing milk production resulting from more frequent milking by a local influence exercised on the secretory cells. As influencing factors he mentions: (1) the level of milk production, (2) the capacity of the udder, and (3) the preparation of the udder and its treatment after milking. Szajkó (1984) reports on a 2–8% increase in milk production as a result of three daily milkings, and points to the role of neurohormonal factors as contributing to the yield improvement. He is of the opinion that twice-daily milking is economical practice in these days, and therefore emphasizes the importance of a large udder capacity.

Milk production, butterfat, milk protein and milk concentration data of our milking cow groups, and some other results concerning lactation are contained in Table 1, with evaluation of: (1) the production level, and (2) the effect of the first, second, third and later lactations. The data show that with a 305-days milk production taken into consideration thrice-daily milking resulted in 12.3% surplus production on a group average in comparison to the twice-daily practice of milking. It must be emphasized, however, that from the standpoint of determining the frequency of milking among others, the result of the first milk record is not a matter of indifference.

Table 1

Effect of milking frequency on the milk production of cows

	Number of daily milkings	Milk production standard+			Lactations			Total
		<26	26–34	>34	1	2	3 and further	
Number of animals	2	33	40	11	25	23	36	84
	3	21	54	14	20	26	43	89
Milk (for 305 days of lactation), kg	2	5675	6468	7011	6054	6031	6464	6228
	3	5669	7069	8681	6798	7078	7033	6992
	Significance	NS	***	***	*	*	*	***
Butterfat, kg	2	223	244	250	231	228	246	236
	3	218	251	292	236	254	253	250
	Significance	NS	NS	*	NS	*	NS	*
Milk protein, kg	2	196	225	237	203	208	232	215
	3	197	245	290	231	241	244	240
	Significance	NS	**	***	**	**	NS	***
Butterfat, %	2	3.93	3.76	3.56	3.83	3.81	3.80	3.80
	3	3.85	3.56	3.42	3.51	3.58	3.61	3.60
	Significance	NS	**	NS	**	*	**	***
Milk protein, %	2	3.53	3.56	3.42	3.37	3.47	3.51	3.53
	3	3.53	3.51	3.46	3.41	3.40	3.47	3.51
	Significance	NS	NS	NS	NS	NS	NS	NS
Days of maximum milk production in typical lactations	2	58	54	55	54	59	56	56
	3	50	57	46	61	49	53	54
	Significance	NS	NS	NS	NS	NS	NS	NS
Maximum milk production in typical lactations, kg	2	23.9	30.0	36.8	25.1	29.8	31.0	29.1
	3	24.2	30.7	37.9	27.2	30.9	31.3	30.5
	Significance	NS	NS	NS	NS	NS	NS	NS

+ On the basis of the first milk records, daily milk production, kg.
NS = P > 0.05; * P < 0.05; ** P < 0.01; *** P < 0.001.

In the case of a lower than 26 kg daily milk yield, no difference in lactation milk production was found between cows milked twice and those milked thrice a day. In a 305-day lactation period the improvement in milk production was 9.2% with cows producing 26–34 kg a day and 23.8% with those producing more than 34 kg. Thus the efficiency of three daily compared to two daily, milkings depends to a considerable extent on the level of milk production.

According to some authors, the effect of milking frequency may vary alike with age and lactation period (Madsen 1983, Tresser 1978, Csiffó 1978). However, our data provide evidence of the positive effect of three daily mikings on the 305-day lactation milk production in the first, second third or later lactations as well. Accordingly, the favourable effect depends on the level of production rather than on the number of lactations.

In the opinion of Archer (1983), with high productivity cows, the peak yield of lactation increases, the period of maximum production lengthens, the lactation curve is more even, the persistence of the cow is better, and he therefore suggests milking three times a day throughout the lactation period. According to Pelissier, Koong and Bennett (1978) cows milked three times a day give 7–12% more milk in the first 4 months of the lactation period and 16–90% more in the rest of the lactation period, than do cows milked only twice a day. Cash and Yapp (1950) and Pearson, Fulton, Thompson and Smith (1979) also found that the effect of daily triple-milking was most favourable at the end of the lactation period. Poole (1981), on the other hand, found that thrice-daily milking was similarly favourable in the first 20 weeks of lactation. Gere, Bozó, Enyedi and Tonka (1984) referring to Soviet authors consider the daily practice of triple-milking justified with cows first in milk. Facsar (1979) reports on a daily milk surplus of three litres in each phase of lactation in the case of milking three times a day. Molnár (1981) as well as Budai and Turi (1984) consider thrice-daily milking reasonable for cows of the best milk production group (over 25 litres a day). To attain a higher than 7000 litre milk production Báldy (1983) milks 90% of the cows three times a day, pointing out that it results in an 8% increase in output.

The lactation curves of cows qualified as medium (daily 26–34 kg milk) and high productivity (over 34 kg) on the basis of the first milking, as well as the results of statistical analyses, prove that the positive effect of three-times milking is realized first of all in the second phase of lactation following the peak, thus improving the persistence. The data on high productivity cows milked three times a day show that the milk production decreases to a lesser extent following the lactation peak than in the case of cows milked twice a day. The days of maximum milk production and the maximum daily amount of milk, on the other hand, were not found in this experiment series to vary with the frequency of milking. At the same time, in the experiment of Budai and Turi (1984) the maximum daily milk production was 33.1 kg with cows milked twice and 38.4 kg with those milked three times a day; the volume of milk obtained in the first four months showed no essential difference, and from the fourth month of lactation onward no difference in persistance was found between the two groups.

(2) As for the composition of milk, Hansson (cit. Schönmuth and Lehmann 1965) suggests a strict judgement at pass on the practice of thrice-daily milking, declaring that the results should be interpreted as converted into FCM, otherwise only "the secretion of water is registered". Similar views are held by Csiszár (1957): "In the case of a high milk production (e.g. 250 kg butterfat a year) the milk output is not subsantially increased by raising the number of milkings from two to three. "If a cow milked three times a day gives a medium amount of milk (e.g. 160 kg butterfat a year), then twice-daily milking will but slightly decrease its milk production. On the other hand, the output of a cow producing 200 kg butterfat a year can be considerably increased by changing over from double to triple daily milkings if the capacity of the udder is small, or if its tissues are less elastic." Guba (1983) is of the opinion that thrice-daily milking has a favourable effect on the butterfat percentage too, besides increasing the amount of milk produced. The effect exercised on the amount of milk is — according to Madsen (1983) — more dramatic than the influence on the increase of butterfat.

Studying the course of milk formation Turner (1953) emphasizes that the rate of milk secretion following milking remains constant for a rather long time and is not controlled by the increased pressure caused by the accumulation of milk, as was thought earlier. So the inhibitory effect on secretion needs revision. The actual course of milk- and butterfat synthesis is linear for about 14–16 hours (Ormiston, Spahr and Touchberry 1967).

At the same time, in the experiment of Wheelock, Rook, Dodd and Griffin (1966) with the lengthening of the milking interval the secretion of milk and milk constituents showed a curvilinear decrease, though of a varying extent for the different constituents. The order of decrease was: $Na^+ < Cl^- <$ $<$ fat $<$ whey proteins $<$ casein $<$ N $<$ water $<$ non-protein N $<$ lactose $<$ $< K^+$.

According to Witzel and McDonald (1965) the pressure measured in the udder basin does not necessarily reflect the pressure brought about in the alveoli or in the small collecting tubules in the course of milk secretion. The secreted milk remains there until the pressure becomes normal in the udder. McMeekan and Brumby (1956) report on the rate of milk secretion being constant for 20–24 hours. According to Csiszár (1957): "Lactation is in fact a process that can be represented by a line steadily rising at an angle of about 30–40 degrees for 15 hours following milking, then slightly flattening after the 15th hour". Discussing the intensity of milk synthesis Guba and Dohy

(1979) definitely refer to the role of pressure conditions; when the pressure rises to 30–40 Hgmm the secretion stops. For this reason the milking interval should not be longer than 8 hours which, compared to the 12 hour interval, may result in a 15–20% milk surplus.

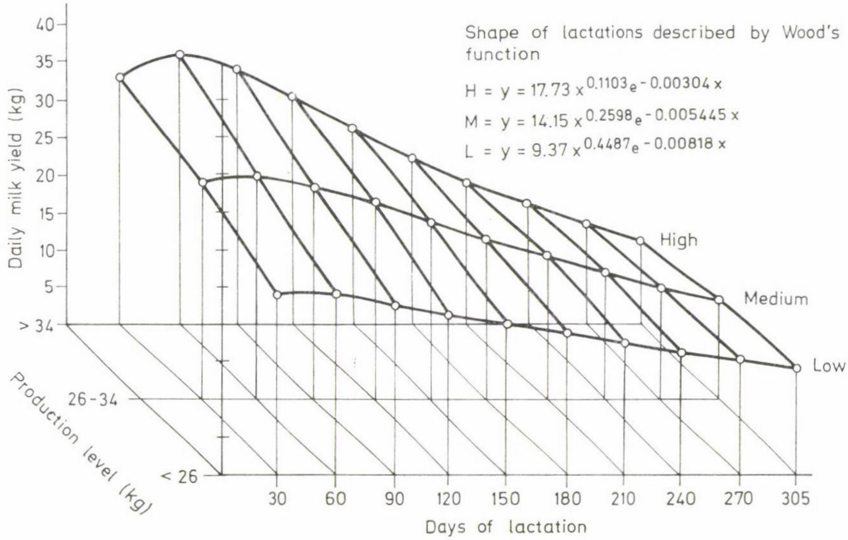

Fig. 1. Lactation curves for the group of cows milked twice a day

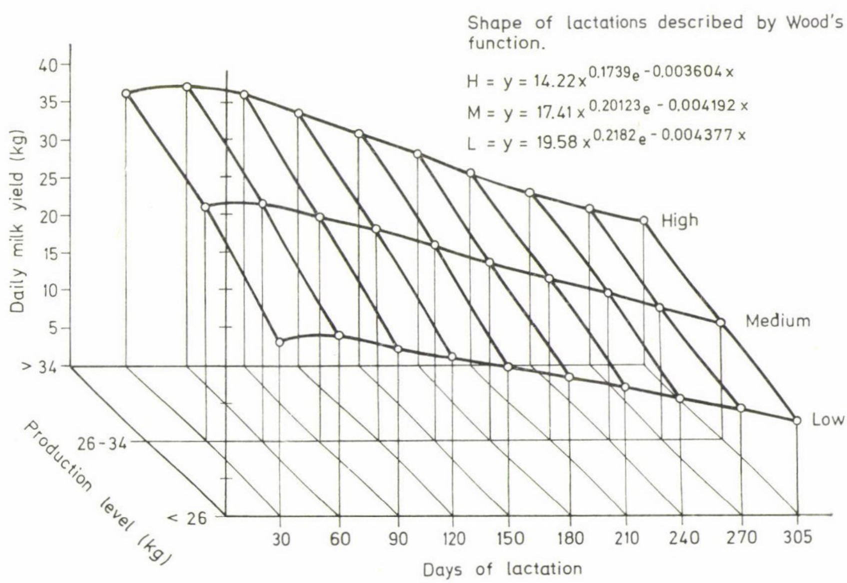

Fig. 2. Lactation curves for the group of cows milked thrice a day

The results of investigations (Table 1) show that on increasing the number of daily milkings from two to three some reduction in the fat content of milk must be reckoned with in each lactation. The sharpest reduction (8.4%) was observed with cows first in lactation; this percentage was lower in the second and subsequent lactations (6.3% and 5.2%, respectively). However, as regards the amount of butterfat produced, this did not present problems; on the contrary, in the case of cows of second lactation even an 11.4% increase in butterfat production was observed. As a result of thrice-daily milking the butterfat content of milk produced by medium and high capacity cows was lower by 5.3% and 3.0%, respectively; still, the total butterfat production

Table 2

Feed and nutrient consumption and feed conversion in the experiment

	Frequency of milking	
	2×	3×
Number of feeding days	26 641	26 746
Milk production total, kg	584 122	704 753
daily, kg	21.9	26.3
Feed consumption, q		
maize silage	3 024	2 864
fresh lucerne	1 588	1 541
cobmeal	1 175	1 237
lucerne hay	792	797
lucerne silage + cobmeal	1 930	1 935
compound feed I.	182	174
compound feed II.	74	77
milking concentrate I.	528	647
milking concentration II.	436	420
maize meal	618	642
fresh sliced beetroot	1 582	1 605
Nutrient consumption		
dry matter total, q	5 260	5 361
daily, kg	19.74	20.05
starch equivalent total, q	3 243	3 325
daily, kg	12.17	12.43
digestible crude protein total, q	615	635
daily, kg	2.31	2.37
Nutrient conversion[1]		
starch equivalent g/kg milk	559	473
digestible protein g/kg milk	106	90

[1] Requirement for maintanence included

— mainly of high capacity cows — showed a 16.8% improvement in response to milking three times a day. The milk protein content did not change in any considerable measure; the increase in the quantity of milk protein was, in essentials, proportionate to the increase in the amount of milk.

(3) Apart from milk production in the 305-day period of lactation, we analysed the milk production, feed consumption, nutrient uptake and feed conversion for the two groups of cow separately. The results of the analysis are summed up in Table 2. We found a 20.7% surplus of milk production in favour of the group milked three times a day. This result is in full agreement with our earlier findings. The nutrient intake, on the other hand, increased but slightly: for starch equivalent the increase was 2.5% and for digestible crude protein 3.3%. Madsen (1983) mentions an improvement in feed conversion in response to milking three times a day. Referring to American experiences, Tresser (1978) speaks of a mere 5% increase in feed requirements, despite a 15–20% increase in milk production in the case of triple milking. The cow's appetite improves, but a more concentrated feed is required. In our experiment the starch value conversion ratio improved by 15.4% and the conversion of digestible crude protein by 15.1% possibly because in the case of higher milk production the amount of feed required to maintance per unit quantity of milk is smaller.

Conclusions

Milking three times a day throughout the whole lactation period is worth consideration with those cows whose milk production exceeds 26 litres at first milk records.

On grouping the cows after calving, groups to be milked twice an three times, respectively, should be formed with the above taken into consideration. The positive effect of thrice-daily milking on milk production shows in each lactation.

Increase is the greatest with high productivity cows.

As a response to daily triple-milking the butterfat content slightly decreases while the milk protein content does not change.

Yet, as a result of a surplus of milk production the actual amount of butterfat increases; in the amount of milk protein the increase is more pronounced.

The favourable effect of thrice-daily milking first appears in the period following the lactation peak, and the extent of this positive effect keeps growing with the progress of lactation.

The phenomenon is explained as follows: cows milked three times a day keep their milk better, they persist better, and this tendency is particularly remarkable in the case of high productivity cows, as they drop the milk to a lesser extent in the longer descending phase of the lactation curve than do cows milked twice a day.

It can be established that the dairy practice both in Hungary and abroad has recognised the importance of daily triple-milking. With our study we wished to support the reasonableness of this practice with definite measurements, calling attention to some opinions upon which insufficient light has been thrown so far. However, the practice of thrice-daily milking is worthwhile only in the case of milk production above 6000 kg, and miracles cannot be expected from it. It will function efficiently only in dairies with an otherwise adequate level of operation, keeping and feeding.

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Acta Agronomica Hungarica, 37 (1–2), pp. 135–143 (1988)

STUDIES ON THE FREQUENCY OF BOVINE MASTITIS INCIDENCE AMONG DAIRY COWS OF DIFFERENT GENOTYPES

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(Received: 21 February 1985)

Mastitis tests were carried out by the authors with cows of different genotypes. The relationship between the rate of mastitis incidence and each of the following factors was also investigated: distance between the ground and the teat tip, distance between the teats, lengths, diameter and angle of deviation of the teats from the vertical direction, milking capacity and udder index.

Data from studies on udder morphology were evaluated by the aid of a computer of the R-20 type.

In the course of the experiments, it has been observed, that the genotype of the animal and udder morphological features play a less important role in mastitis development then has been thought. Therefore, according to authors, still greater emphasis should be laid in future on the training of staff, who would be entirely able to realize keeping technological measures.

Keywords: Cows, mastitis, udder morphology.

Introduction

Judgement of the suitability of the udder for machine milking, with knowledge of the variety, is discussed in the literature dealing with cattle breeding. The vast majority of these judgements was based on the percentage distribution of mastitis incidence among different varieties, as it has been determined by different methods of examination. In the case of the varieties of countries with highly developed breeding culture, it may be stated that mastitis incidence is of a lesser importance with machine milking. This is mainly attributed to the fact that, in the course of breeding, selection was made in addition to milk production also for udder morphology. In udder judgements of such a tendency, however, skill and affection for animals of the milkers and keepers, keeping conditions, types of milking machines, etc. were never considered. Effects of these various factors have been mostly neglected and only the final result, i.e. frequency of mastitis incidence was taken into account and it was attributed exclusively to the varietal susceptibility to mastitis. Studies on mastitis incidence among different breeds, carried out under identical conditions, have been made by only very few workers. Therefore, comparison of the results would not be reasonable.

Simultaneously with transformation cross-breedings, carried out in order to obtain increased production — in the hope of higher profit — improved conditions were assured for dairy cows, which mean at the same time better feeding, health provision and redistribution of the most skilled milkers and keepers.

In such a case it was experienced that, in identical farms with identical feeding possibilities and sanitary conditions, mastitis negativity was 65% in the Hungarian spotted × Holstein friesian F_1 cattle stock, while only about 15% of the Hungarian spotted stock, to be sorted out, proved to be negative. The cause of this marked difference could be traced back — as it became subsequently evident — to the fact that most qualified milkers and workers being fond of animals were charged with taking care of the F_1 population while mistreatment of the animals was characteristic of the Hungarian spotted stock. On one occasion, when the door of the stable was opened, all cows nervously trembled with fear. Later, the causes of this behaviour could be discovered, by noticing the wounds and pinholes on the legs and flanks of the cows, because of stabs made with a pitchfork. Nevertheless, cleanliness and tidiness prevailed in the stable and fresh straw was found at all times under the animals. The atmosphere, however, in which cows shuddered from fear even at the slightest noise, inhibited — presumably — also the milk furnishing capacity of the cows, resulting in a higher degree of mastitis incidence. A counter-example of this was found in the stock breeding farm of the co-operative at Kocsér, where the best cow-keepers were employed to care for the Hungarian spotted variety, and where there was about 90% of the stock mastitis negative. In the Hungarian spotted × Holstein friesian F_1 herd of the same co-operative, a higher percentage of mastitis incidence was found.

The importance of the human factor was emphasized also by Gooding, who stressed that, in addition to unskilled milking, inconsiderate treatment and careless maintenance are the main causes of mastitis development.

The significance of affection for animals and conscientious maintenance is pointed out in the study by Szajkó 1976. According to him, milking time, speed of milking, occurrence and duration of empty milking are markedly influenced by preparation of the udder, having an effect also on its health condition.

These studies partly explain why mastitis was of lesser importance in the case of hand milking, under small scale conditions, making possible that more skilled keepers, being fond of animals, could spend more time on dealing individually with the animals.

The increase in concentration and mechanization of milk producing farms, however, makes stocks more and more sensitive, providing greater opportunity for occurrence and enhancement of technological faults. Since in many cases, the proportion of workers who are fond of their profession decreases among dairy men, they tend to overcome these deficiencies by the aid of advanced technology. The higher technological level, however, would require more skilled staff. This question may be finished — without further analysis — by the conclusion that severe diseases of dairy cows are in causal correlation with a number of other factors. This means that a system of conditions is necessary for the development, maintenance or cessation of the effect. In other words, cause may only elicit its effect, if conditions for the same subject were identical.

Material and methods

Experiments were carried out between 1973–1982 in 6 state farms and 36 farmers' agricultural co-operatives. The examinations were finished simultaneously with those made by the Herd Book Advisory Board. Mastitis was detected by the aid of the mastitis trial.

To elucidate the relationship between udder morphological features and mastitis incidence, the udder and teat sizes of 975 dairy cows were evaluated in the following manner.

The distance between the ground and the teat tips as well as the length of the teats were determined by the aid of a millimetre-scale measuring rod.

The diameter of the teats was measured with a slidge-gauge. The determination of the angle of deviation of the teats from the vertical direction was made by the application of a measuring network, constructed specially for this purpose, by the aid of which distances between the teats as well as those of the teat bases could be found. From the resulting data, subsequently the angle of deviation of the teats from the vertical direction was established by the aid of squared plotting paper and an anglemeter.

Method of udder examination

The distance between the teats and the ground and the length of the teats were determined with a millimeter scale measuring rod. The diameter of the teats was measured with a slide-gauge. The deviation of the teats from the vertical direction and the distance between the teat bases were determined by the application of a measuring network, constructed specially for this purpose. From the data obtained, the angle of deviation from the vertical direction was later established by the aid squared plotting paper and an anglemeter.

Description of the measuring network, constructed for udder examination

A solid iron framework of 100×100 cm size was prepared, onto which green wires fixed both horizontally and vertically at a distance of 1 cm apart. To facilitate readings, instead of green wire, black marking wires were inserted at every 5 cm distance. Graduations on the left side and upper edge of the framework were denoted by serial numbers, starting off from the upper left side corner of the upright framework. By the aid of these graduations, also the length of the teat could be easily read and determined and in other cases, the distance between the teat bases (see Table 1).

From these measurements, the deviation of the teat from the vertical direction also became easily detectable. This measuring network could be successfully used in the course of studies on udder increase, too. In this case, udder area could be recorded from behind, in plane also by photograph, and from the lateral position as well as after drawing aside the tail of the animal. After planimetrization of the photographs made in this manner, the size of udder area measured in the plane was obtained. In the course of additional research work, the increase in the udder size of heifers up to calving, and subsequent udder morphological changes occurring during lactation, were studied with the aid of the measuring network.

The use of the measuring network

Cows are led to a site of plain floor, and the measuring network is set up close to the animal — immediately next to the udder, or in other cases, behind the hindquarter. Thereafter, corresponding data may be read from the network. Reading distance from the network should be between 3–6 m. Workers, who are reading the data or making photographs from the udder, must not remain constantly at equal distances from the subject under study (in this case, from the udder) since, according to the rules of perspective, if one stands nearer, not only the udder (or teats) seem to be larger, but also the graduation of the measuring network. The exact opposite is true for the more remote position.

Processing of the data

The udder morphological data were arranged, and thereafter programmed together with the results of mastitis teats, into a computer of the R-20 type, and evaluated by correlation calculation. In addition to statistical evaluation, diagrams were also constructed, for a better demonstration.

Evaluation of udder morphological examination

In the course of the experiments, distances between fore, hind, left and right teats, resp., and the ground, length and diameter of the teats, distances between the teats, and level differences between the teat bases were separately evaluated.

In addition to the binary functional relation, a multiple correlation analysis was also used to clarify the role of each variable in the determination and development of relationships.

Results and discussion

Evaluation of the investigations

In evaluating nearly 30 000 dairy cows of different genotypes, significant differences between the rate and frequency of mastitis could not be demonstrated by statistical methods of calculation. This may be due — presumably —

Table 1

Frequency of mastitis incidence among different dairy cattle genotypes

	Reaction		Hungarian spotted	Hs × Holst. friesian F_1	Hs × Red friesian F_1	Holstein friesian	Ayrshire	Total
	Negative	No.	3283	8 969	5906	305	163	18 626
		%	61.40	63.13	66.20	65.87	66.0	63.82
Positive	+	No.	577	1 313	866	32	23	2 811
		%	10.79	9.24	9.71	6.45	9.50	9.63
	++	No.	716	1 990	990	56	29	3 781
		%	13.39	14.01	11.10	12.09	11.70	12.95
	+++	No.	577	1 332	749	47	21	2 706
		%	10.42	9.38	8.39	10.15	8.50	9.27
	++++	No.	96	296	189	10	5	594
		%	1.80	2.08	2.10	2.05	2.10	2.03
	Clinical	No.	118	308	223	13	6	668
		%	2.21	2.17	2.50	2.79	2.40	2.29
Total		No.	5347	14 207	8922	463	247	29 196

to the lack of identical conditions until now, under which different genotypes could be compared, with respect to maintenance, feeding and milking technologies, as well as the supply of milkers of the same qualification and conscientiousness. The results of investigations are demonstrated in Table 1.

Since we wanted to satisfy this question completely, examinations were extended to various studies on udder morphology. In our experimental work we started from the fact optimum distance between the teat tips and the ground was regarded as 45–50 cm by a number of authors (Hámori, Horváth, Katona 1970; Kováts et al. 1973, 1974) reported, that the optimum distance was 50 cm.

In relation to short legs, also teats longer than 9 cm are looked upon as predisposing factor to mastitis because of the risk of being trampled by the feet. Substantially, a different frequency andrate of mastitis incidency among various genotypes is mainly traced back to these factors. The optimum length and diameter of the teats may be regarded as 5–6 cm and 20–22 mm, resp.

In contrast with earlier statements, it was suggested by McDonald (1977) that a predisposition to infection is not influenced by the length of the teat duct. It was also found that, if the width of the teat duct diameter surpasses that of the average, there is an increased predisposition to mastitis development.

It was reported by Johnson (1975), that the speed of milk furnishing is advantageously influenced by wide, short teat ducts, although thereby the possibility of access of pathogens to the udder is increased, while the opposite is true for narrow, long teat ducts. Zeman et al. (1973) reported that a predisposition to subclinical mastitis increases with the speed of milk furnishing.

It is considered important by most of the manuals for animal breeding that investigations on udder index and speed of milking should also be carried out, because the prediction of health conditions of the udder is to be expected. In addition to the factors listed above, we examined also the deviation of the teats from the vertical direction as well as the distance between the teat bases.

Evaluation of the distance between teat tips and the ground

Frequency of mastitis incidence in the case of a distance of 45–50 cm between the teat tips and the ground — which has been considered as optimum — is clearly shown in Table 2.

Correlations were also calculated for all teats and, in this case, the value of "*r*" was — 0.323. The scattering of the distance between the teat tips and the ground was 1.89 cm (s).

The udder, when in a lower position, inhibits the setting up of the milking machine and in this case, the collector of the milking machine gets onto the surface of the platform, so that the teat may be bent and tissue

Table 2

Evaluation of the effect of the distance between the teat tips and the ground

Teat	Value of correl. (r)	Percentage distribution of distances between teats and the ground		
		44.9 cm	45–50 cm	50.1 cm
Fore, right	-0.280	36.8	53.1	10.1
Fore, left	-0.236	35.5	55.2	9.3
Hinder, right	-0.126	39.2	50.0	10.8
Hinder, left	-0.098	29.7	56.2	14.1

damage may occur. In our opinion, the bending of the teats bears a greater causal relationship with mastitis development than the increased possibility of infection of the teats situated nearer to the ground.

Evaluation of the teat length

The results of studies on teat length are summarized in Table 3. It can be stated that the teat length does not exert a significant influence on mastitis ($r = 0.1743$).

Evaluation of the teat diameter

The results of studies on teat diameter are presented in Table 4. Correlation analyses show that the teat diameter is only slightly realted to mastitis positivity ($r = +0.218$).

Evaluation of the distance between the teats, level difference between teat cases and angle of deviation from the vertical direction

The angle of deviation of the teats from the vertical direction is slightly correlated with mastitis ($r = +0.223$). The introduction of two variables, i.e. the teat length and the angle of deviation from the vertical direction, however, resulted in a higher degree of correlation ($r = +0.349$).

The closest correlation was demonstrated between mastitis incidence and animals with udder morphological disorders ($r = 0.496$). In the course of more comprehensive studies on this subject, it was also recognized that the teats which deviated from the vertical direction, were not the most frequently diseased — as would be expected because of bending, caused by the milking machine — but those of regular position. This occurs because of the fact that teats of a regular position may be milked out more rapidly and thus the duration of blind milkings increases, which leads sooner or later to mastitis development.

Table 3

Evaluation of the length of the teats

Teat	$\bar{X}$ (cm)	s (cm)	V (%)	Lim (cm)
Fore, right	7.37	1.694	22.98	3.0–11.5
Fore, left	8.33	1.072	12.86	8.0–10.5
Hinder, right	6.69	1.442	21.50	4.5– 9.5
Hinder, left	6.77	1.493	22.05	5.0–10.0

Table 4

Evaluation of the diameter of the teats

Teat	$\bar{X}$ (cm)	s (cm)	V (%)	Lim (cm)
Fore, right	28.88	0.42	1.454	23–40
Fore, left	31.31	0.44	1.405	23–40
Hinder, right	29.83	0.46	1.542	24–43
Hinder, left	30.06	0.35	1.164	24–42

Table 5

Relation between the speed of milking and mastitis

Speed of milking, l/min	Results of mastitis tests		Total, %
	healthy, %	diseased, %	
1.41–2.20	48.6	51.4	100
2.21–2.80	56.8	43.2	100
2.81–3.60	50.0	50.0	100

Table 6

Relationship between udder index and mastitis

Udder index, %	Results of mastitis tests		Total, %
	healthy, %	diseased, %	
38.1–49.9	47.1	52.9	100
50.0–50.9	47.9	52.1	100
51.0–55.0	40.0	60.0	100

Correlation between the speed of milking and mastitis

It can be concluded from the results in Table 5 that secretory disorders occur more frequently among dairy cattle that are milked with a higher or lower speed than the average. A very weak correlation appears between the speed of milking and mastitis ($r = 0.1200$). Therefore, no conclusion can be drawn from the speed of milking with the susceptibility to mastitis.

Correlation between udder index and mastitis incidence

From the grouping in Table 6 it may be stated that in the case of udder indices above 50%, the proportion of mastitis increased although the practical correlation could not be established by calculations ($r = 0.143$).

Conclusion

On the basis of our investigation, it can be stated that the genotype of the dairy cattle and their udder morphological features play a less important role in mastitis development than has been previously considered.

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Acta Agronomica Hungarica, 37 (1–2), pp. 145–154 (1988)

Lectures

SELECTING HYBRIDS FOR SILAGE MAIZE PRODUCTION*

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(Received: 20 October 1986)

There have been several attempts to develop superior performing hybrids for silage production. Material that has been radically different from the conventional grain hybrid has been disappointing. An examination of current information suggests that hybrids developed specifically for whole-plant silage production will not look materially different than a grain hybrid. Major emphasis in selection will be on whole-plant dry matter (DM) yield with less emphasis on grain yield, stalk lodging resistance, plant barrenness and maturity.

In Canada, hybrids currently on the market were developed for grain production. A study was conducted to determine the relationship between grain yield following grain maturity and whole-plant DM yield and quality determined at the silage harvest stage. There was a significant linear relationship between grain yield performance and silage yield. However, the relationship was not complete enough to permit reliable selection of hybrids for silage production based on grain yield performance.

Preliminary results of a recurrent selection program aimed at the development of improved germplasm for silage production are reported. Selection of S_1 lines based on whole-plant yield in silage trials was more effective in increasing whole-plant DM yield than selection of S_1 lines based on grain yield in grain production trials.

Keywords: *Zea mays* L., silage production, silage hybrids, recurrent selection, digestibility, corn.

Background

Maize is a very important forage species. As a forage it is used primarily in the production of whole-plant maize silage. Canada currently has in the order of 400,000 ha of maize grown for maize silage production. Throughout both North America and Europe the primary objective in the production of maize for silage production have been high dry matter (DM yield) per unit area of land, high quality for ruminants and a high enough DM content to ensure proper ensiling with minimum losses as well as high animal DM intake.

Until recently, corn breeding efforts have concentrated on the development of germplasm and hybrids for grain production. To a large extent, production practices have also been those determined for grain maize production.

* The paper was presented at International Forage Research Congress held in Mosonmagyaróvár, August 27–29, 1986.

At Guelph, our initial silage research examined field production practices for silage maize relative to grain maize production. It is not my intention to spend much time reviewing the research on silage production practices. However, it is worth noting that the Ontario Government does recommend higher planting densities and longer season hybrid when maize corn is being grown for silage production. Our current approach suggests that planting densities about 20% higher than recommended for grain production will result in increased yields of DM with little or no loss of quality. In terms of hybrid maturity, we suggest that farmers consider growing hybrids for silage that are about 200 Ontario Corn Heat Units (Brown 1978) later than recommended for grain. This amounts to a rating of FAO 300 rather than FAO 200 or approximately two weeks in the fall. The other suggestion we make is that it is more important for a farmer to plant his grain maize early than his silage maize. However, it should be pointed out that delayed planting of maize for silage production does result in reduced yields of DM and a greater rist of immature maize and delayed harvest in the fall. The reason for this recommendation is that delayed planting reduces grain yield relatively more than whole-plant yield. In addition, the problem of delayed maturity for grain is more critical since the grain component is the last to develop. Any reduction in grain yield, therefore, results in a loss of the only component to be harvested. This is not true for whole-plant yield, where the effects of delayed maturity on grain component yield are counterbalanced by the effect on stover yield (Daynard and Hunter 1975).

Recent research has examined the effect of stress on the performance of maize when grown for silage compared to grain production (Mbewe and Hunter 1986). Shading stress applied at each of three stages of development, vegetative, reproductive, and grain filling, all resulted in a reduction in whole-plant DM yield relative to a non-shaded control. The reduction in yield was similar in magnitude for all three shade treatments. In contrast, grain yield was reduced far more when the stress was applied at the reproductive stage compared to stress at the vegetative or grain filling stages. In the case of whole-plant yield, there was no similar reduction from reproductive shading because a higher stover yield compensated for the reduction in grain yield.

Having briefly discussed some of the production practices and the stress response of maize grown for silage production, the remainder of this paper will examine the role of the genotype in silage production. The brief discussion on production practices supplies some information on what cultural practices will be used, at least at the present time, for maize that is grown for silage.

Silage ideotype

In a search for better "silage hybrids", considerable research effort has examined a number of "different" maize types. In search of higher DM yields, researchers have examined tillering maize (Freyman et al. 1973) extremely late maturing maize that is very tall and leafy (Hunter and Kannenberg 1970) and barren or male sterile plants (Perry and Caldwell 1969). None of these approaches has shown much promise for increasing DM yields. In addition, maize genotypes producing little or no grain (very late maturing material or barren or male sterile corns) have been found to have moisture contents higher than desirable for making good quality silage. Attempts to provide silage genotypes with better quality have included the use of dwarfing genes (Byers et al. 1965) and tillering germplasm (Bowden et al. 1973). Once again, no clear advantages have been demonstrated. An exception to this is the feeding value of brown midrib material (i.e. maize containing the *bm3* gene). Such material has been demonstrated to be lower in whole-plant lignin content (Muller et al. 1971). The result has been improved feeding performance as demonstrated by, for example. Colenbrander et al. (1975). Unfortunately, the field performance of brown midrib germplasm has been found to be inferior to normal material.

In summary, at the present time, there do not appear to be radically different maize genotypes that will make a major contribution to improving quantity and/or quality of maize grown for whole-plant silage. If we are not looking for anything radically different, what then are we looking for?

There is not a great deal of information suggesting what constitutes a silage hybrid. As stated earler, we know the objectives, but how to obtain these objectives in a breeding program has been less clear in North America, where most breeders do not select material for silage performance, but rather rely on the concept that the best grain-yielding hybrids are the most suitable for silage production. This approach is based primarily on the work conducted in the United States in the 1930's and 1940's (i.e. Nevens 1933). These early comparisons concluded that in general the best grain genotype also produced high yielding, high quality forage at a DM content suitable for ensiling. The concept was supported by the fact that the grain is high in quality relative to the stover. It is also possible that maize breeders accepted the premise of choosing silage hybrids based on grain yield performance because it eliminated the time and expense of separate breeding and evaluation programs. This would be a major consideration in regions where the silage maize acreage constitutes a relatively small proportion of the total grain acreage. Clearly, in such regions, resources are better spent on evaluation for grain yield.

In many of the shorter season areas into which maize has recently expanded, silage maize production plays a relatively greater role. In some areas almost all the maize is used for silage production. Maize researchers in such areas are questioning the concept of selecting the best grain hybrid and using them for silage. For example, in France, Gallais et al. (1976) found no relationship between the proportion of grain in hybrids and total DM yield. They did find hybrid differences for forage DM yield. Their conclusion was that it is necessary to obtain maximum development of all parts of the plant in order to obtain highest yields. Stalk height and diameter as well as leaf dimensions have been reported to be related to whole-plant DM yields (Gallais et al. 1976; Craig 1966). However, it would not be a suitable strategy simply to select for these traits without a careful monitoring of maturity or else the selections would undoubtedly reflect maturity shifts in addition to the DM yield gains. In shorter season areas, this would result in low whole-plant DM content due to reduced grain content.

Under Canadian climatic conditions the most direct approach to obtaining a DM content acceptable for making good whole-plant silage is to grow genotypes that produce a fairly high proportion of grain. It is not necessary to wait for maximum grain production (black layer) in order to obtain a high enough DM content. By the time the plant has attained 85–90% of maximum grain yield, the whole-plant DM content will be close to 35% (Daynard and Hunter 1975). At this stage, grain moisture will be about 44%. In other words, there is research that supports the concept that high grain content *per se* should not be the goal of silage production. However, it is necessary to have sufficient grain content to assure a DM content suitable for ensiling. In Canada we normally think in terms of 35% DM, which would relate to 40%, plus grain content. In the short-season areas of Europe, 30% or even 28% DM content might be considered a reasonable maturity target. This target can be realized with a lower grain content (i.e. less mature material).

It is well documented that the longer maize remains in the field, the more subject it is to stalk lodging resulting from stalk cell senescence and stalk rots (Twumasi and Hunter 1982). In addition, maize grown under increasing stress has been demonstrated to be more prone to lodging. Higher planting densities result in increased stress and, therefore, increased lodging susceptibility. Since maize utilized for silage is harvested at both an earlier date and at an earlier stage in development than maize grown for grain production, there is less opportunity for serious lodging. Counteracting this tendency is increased stalk lodging resulting from increased planting densities often associated with silage maize production relative to grain maize production. Taking these two factors into account, it would appear to me that selection criteria utilized in obtaining material specifically for silage maize production will not require the same selection pressure to obtain a satisfactory level of stalk lodging resistance as when maize is being selected for grain production. This should be the situation, despite increased plant densities associated with maize for silage. However, I know of no research that clearly examines and supports the above contention.

With the above background information, it is of alue to hypothesize, in general terms, what might constitute a good silage hybrid. The picture being painted is by no means complete, but it does offer a meaningful sketch. A silage hybrid, at first glance, will probably not look noticeably different from a grain hybrid. It will probably produce a single ear on a single stalk. The grain to stover ratio will be dictated more by maturity requirements than by yield of quality. The grain to stover ratio at harvest will be in the order of 0.65 : 1.00 or in very short-season areas even lower. The emphasis need not be placed on maximizing grain yield, but more importantly will be place on high whole-plant DM yield.

The emphasis on maturity of grain can be less rigid for silage maize since the grain need not reach physiological maturity prior to the end of the growing season. In addition, less emphasis is required on selecting for stalk lodging resistance and plant barrenness. The reduced emphasis on stalk barrenness, lodging resistance, grain maturity and grain yield should improve progress in selecting for high whole-plant yield. This will be especially true in short-season areas where selection for maturity and stalk lodging resistance are major factors required for hybrids to be used for grain production.

Selection for root lodging resistance and general plant health must be maintained or even increased when selecting maize for silage compared to grain production. The increased emphasis would be related to increasing stress resulting from the increased planting densities often used for silage maize production.

To date, the portion of the picture dealing with quality is not well outlined. There is some evidence that variation exists for improved stover digestibility, but care must be taken not to simply confuse stalk digestibility differences with maturity differences. As with yield, it is whole-plant digestibility that is important. The potential for selecting for this trait is not clear. There are some indications that selection for higher protein levels would be possible. However, in the North American context, considerable effort expended upon selecting for higher protein content is not warranted.

Grain versus silage

In Canada, all maize hybrids, currently on the market, were selected for grain yield traits only. It would be of value to determine what level of variation for silage performance traits exists within these grain hybrids and whether or not their grain yield performance predicts their merit for silage corn production. Trials (Vattikonda and Hunter 1983) conducted at two locations over a two-year period, examined all hybrids currently recommended for grain production in the areas involved. A total of 81 hybrids were tested for the two-year period. The range of variation that existed between hybrids for whole-plant yield, maturity and quality was examined. In addition, the relationship between whole-plant yield and quality when harvested at the correct stage for silage production was compared with a hybrid's performance under a grain production scheme.

The major conclusions from this study are:

— There was a significant linear relationship between the performance of hybrids for grain yield production and their yield for silage production. However, the coefficients of determination (0.23 and 0.25 for locations one and two, respectively) were not large enough to permit reliable selection of hybrids for silage production nased on grain yield performance.
— Grain DM content provided a satisfactory estimate of whole-plant maturity for silage production. The coefficients of determination between grain DM content and whole-plant DM content were 0.71 and 0.53 for locations one and two, respectively.
— For whole-plant yield, there was at least as much hybrid variation on a relative basis, and two times the hybrid variation on an absolute basis as there was for grain yield, in the grain yield component of the trials.
— There was considerable variation between hybrids for stover digestibility and stover lignin content at the time of harvest for silage production, but less variation existed for protein content.
— There was no significant relationship between per cent grain in the silage and the digestibility of the stover component. In addition, there was no correlation between whole-plant DM content and whole-plant digestibility. This suggests that it may be possible, given the reasonably narrow range of maturities examined, to obtain material with high forage quality independent of hybrid maturity and grain content.
— Whole-plant digestibility was related to both the content of grain in the silage and to the digestibility of the stover component.
— No strong relationship existed between plant characteristics such as plant height, stalk diameter and resistance to lodging and silage performance parameters such as whole-plant yield and quality.

In summary, the findings of this study support the need for separate evaluation trials for maize grown for whole-plant silage production as opposed to grain production. Largely as a result of this research, the Province of Ontario initiated a silage hybrid maize testing program in 1984. Factors evaluated include whole-plant yield, whole-plant maturity and quality as determined by *in vitro* dry matter digestibility and protein content.

Breeding for silage hybrids

There is very little reported in the literature on the results of actual selection schemes aimed at selecting material for silage performance traits as opposed to grain traits. Research at Guelph is currently underway with the following objectives:

- To determine the progress that can be made when selection is based on silage performance parameters.
- To determine if the germplasm selected for improved whole-plant yield and/or quality is of greater utility for silage production than corn selected for grain yield performance.
- To determine the changes in plant characteristics that are associated with the selection of germplasm for whole-plant silage production.

The selection scheme being employed involves S_1, *per se* recurrent selection utilizing two populations. CG Syn A and Wigor. CG Syn A is a Guelph population derived from early dent germplasm from North America and Wigor represents early flint germplasm from Europe. Selection in five separate directions has been imposed in the synthetic CG Syn A (Cycle 0). Selection was based on

(1) high whole-plant yield per unit area of land,
(2) high whole-plant *in vitro* digestibility,
(3) low whole-plant *in vitro* digestibility,
(4) high yield on *in vitro* digestible dry matter per unit area of land,
(5) high grain yield per unit of land.

For Wigor, selection is based on only two traits as follows:

(1) high yield of *in vitro* digestible dry matter per unit area of land,
(2) high grain yield per unit area of land.

The selections involving whole-plant yield and quality (CG Syn A selections 1, 2, 3 and 4 and Wigor selection 1) were based on S_1 performance traits utilizing a production scheme for silage production. The selections for grain yield were based on tests utilizing cultural practices suitable for grain yield.

To date, two cycles of recurrent selection have been completed. The cycles are compared in silage yield trials in 1984 and 1985 and in grain yield trials in 1985. Table 1 presents both grain and whole-plant yield information for the C_0, C_I, and C_{II} populations of Wigor when S_1 selection was based on grain yield or on whole-plant digestible DM yield. The information is preliminary but does provide some indication of the effect of the two selection criteria. Selection based on both grain yield performance and yield of digestible DM resulted in improved whole-plant yield performance in the silage trials and improved grain yield performance in the grain trials. However, for silage yield performance, the material selected for high yield of digestible DM resulted in higher silage yields than when selection was based on grain yield.

Table 1

Whole-plant dry matter yield (t/ha) and from separate trials, grain yield (t/ha) of the C_0, C_I, and C_{II} populations of Wigor selected in an S_1 per se recurrent selection program for high grain yield or high yield of digestible dry matter

Type of evaluation	Selection criteria	Cycle		
		C_0	C_I	C_{II}
Silage yield	Grain yield	6.0	6.6	8.7
	Whole-plant digestible DM yield	6.0	8.3	10.2
Grain yield	Grain yield	2.2	2.7	3.5
	Whole-plant digestible DM yield	2.2	3.2	3.4

Table 2

Whole-plant DM yield (t/ha) and from separate trials, grain yield (t/ha) of the C_0, C_I, and C_{II} populations of CG Syn A selected in an S_1 per se *recurrent selection program for high grain yield, high dry matter yield and high yield of digestible dry matter*

Type of evaluation	Selection criteria	Cycle		
		C_0	C_I	C_{II}
Silage yield	Grain yield	9.9	10.3	10.1
	Whole-plant yield	9.9	10.4	10.7
	Whole-plant digestible DM yield	9.9	10.6	11.6
Grain yield	Grain yield	3.8	3.7	3.5
	Whole-plant yield	3.8	3.6	2.8
	Whole-plant digestible DM yield	3.8	4.2	3.6

Table 3

Whole-plant in vitro *digestible dry matter per cent of the C_0, C_I, and C_{II} populations of CG Syn A involved in an S_1* per se *recurrent selection program*

Selection criteria	Cycle		
	C_0	C_I	C_{II}
Grain yield	71.3	69.9	70.8
Whole-plant DM yield	71.3	70.1	71.6
Whole-plant digestible DM yield	71.3	70.7	71.3
High digestibility	71.3	69.4	71.4
Low digestibility	71.3	71.1	69.4

There was no apparent difference between the grain yield performance when selection was based on grain yield compared to yield of digestible DM. However, both selection criteria resulted in improved grain yields.

For the population CG Syn A the same comparisons as presented for Wigor in Table 1 are presented in Table 2. In addition, data for CG Syn A selected for whole-plant DM yield is also presented. Selection for high whole-plant DM yield or for high yield of digestible DM resulted in an increase of the population performance level for whole-plant DM (silage) yield. However, when selection was based on grain yield, the increase in whole-plant yield was not apparent. The grain yield performance data appeared a slightly erratic, with no indication that grain yield performance of the population was increased, even when the selection criteria used was the increased grain yield. Table 3 presents the 1984 (1985 data not yet available) *in vitro* digestibility data for the CG Syn A population. Selection for either high or low whole-plant digestibility was not successful in increasing or decreasing digestibility.

In summary, this preliminary information lead to the following conclusions:

— Selection of S_1 lines based on whole-plant yield in silage trials is more effective in increasing whole-plant DM yield than selection of S_1 lines based on selection for grain yield in grain yield trials.

— There appears to be limited prospects of selecting for differences in per cent whole-plant digestibility.

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Acta Agronomica Hungarica, 37 (1–2), pp. 155–160 (1988)

EFFECT OF POST-MILKING ON MILK YIELD AND MAMMARY HYGIENE*

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(Received: 10 April 1986)

Preliminaries

At Mosonmagyaróvár University studies on the suitability of populations for machine milking have been in progress ever since the practice of machine milking was introduced.

The ecological and technological factors acting on milking have a great influence on the quantity and quality of the milk and on the health condition of the udder in the given genetic stocks. All these factors affect the productive period of the herd, i.e. the number of lactations, as well as the number of calves.

There are several critical points in milking operations; examinations were made on the preparation of the udder for milking, the relationship between oxytocin mobilization and the milking technology, the main phase of milking and the factors acting on mechanical post-milking, taking milk hygiene into consideration.

The aim was to develop a milking technology adapted to the biological characteristics of the cow and leading to efficient milking low labour demands and a reduction in the number of work phases for which the milker is responsible.

The objective thus defined can only be attained if the full milking process is completed, i.e. post-milking must be automated if it is to be efficient.

Part of the study on the milking process involved and examination of the importance of post-milking and ways of carrying it out. An instrument was constructed to register and diagrammatically depict the phases of milking (giving the chronological order and quantity of milk), the occurrence and duration of idle milking and naturally the duration and result of mechanical post-milking. The instrument was described in earlier publications (Szajkó 1967, 1980, 1983); therefore, only results related to post-milking are summed up here.

* Lecture held at a meeting the 17. Wiss. Jahrestagung 12 February 1986 Karl Marx Universität, Leipzig (DDR).

Literary survey

Various authors (Clough 1964, Bougler and Laboussiere 1971, Rudowsky et al. 1977) reported on a 2–18% loss of milk and a 5% loss of butterfat due to the omission of post-milking. Szajkó and Kelemen (1980) pointed out a 4–10% decrease in milk production. Mbodj (1984) established the result of post-milking as 471–619 g.

Others (Chilkevich 1968, Brandsmann 1973, Darragoux 1974) did not find any loss when post-milking was not carried out.

In agreement with experts from Karl Marx University, Leipzig, importance was attached to a clarification of the reasons for these conflicting views.

Material and methods

The milking experiments were carried out on state and cooperative farms, first in dairy herds consisting of 100–400 cows and later in herds with over a thousand cows. The investigations were partly model experiments and partly surveys. The populations examined before 1970, were of the Hungarian Simmenthal breed, while Holstein-Friesian or Hungarian Simmenthal × Holstein Friesian cows were examined in later years. The Hungarian Simmenthal cows examined cows originally milked into in stands in cow-sheds, while cows containing Friesian blood were milked on a cross type milking platform.

At the beginning of the investigations a survey was made in each case of the milking technologies applied on the respective farms. Operational errors were spotted and eliminated and a satisfactors milking technology was introduced before starting the experiment.

Only milkers who precisely carried out the prescribed milking operations took part in the experiments.

Objective

The developed milking techniques applied up to 1985 had to be reviewed taken into consideration the physiological characteristics of cows. To this end every element of the process was examined including the applicability of mechanical post-milking and the effect of omitting it.

The aim was to elaborate and automatic machine which would solve the problem of post-milking, an operation carried out with great difficulty by milkers.

The factors examined

Within the framework of the experiment the work of a total of 24 milkers on various farms was observed. The factors influencing post-milking were:

- the method and duration of preparation, and the duration and result (expressed in terms of milk) of post-milking,
- changes in the length of idle milking time between the completion of the main phase of milking and the beginning of post-milking,
- the duration of idle milking after post-milking,
- the milk yielded by post-milking, or the loss subtained if it was not carried out,
- the automation of post-milking.

Results

Correlations between preparation and mechanical post-milking

Preparation was found to have a great influence on the main phase of milking. Particularly characteristic was the effect of a one-minute thorough preparation on the beginning of milking, i.e. on the duration of the initial idle milking period. Here, too, differences were found between the genotypes; the data suggest that for specialized dairy cows a shorter, 35–45-second preparation is sufficient for the ejection of the milk, and for these cows intensive massage is not required either. The quantity of milk obtained in the main phase of milking depended on the preparation and influenced the result of mechanical post-milking.

The quantity of milk obtained by mechanical post-milking was smaller when the preparation was optimum for the genotype, because in this case a larger proportion of the milk was ejected in the main phase of milking.

When the milking apparatus was attached to the udder with hardly any preparation except for pre-milking, the main phase of milking was protracted and the quantity of milk obtained was smaller, while the importance and milk yield of post-milking increased.

The quantity of milk obtained by post-milking increased considerably when the preparation was not satisfactory, or when the time from preparation to the application of the milking apparatus was longer than 100 seconds.

In summary it can be established that the duration and intensity of preparation have an indirect effect on the result of mechanical post-milking due to their influence on the quantity of milk obtained in the main phase of milking. An improvement in the preparation also led to an increase in the total amount of milk obtained though the differences were not significant.

As a result of intensive preparation the duration of post-milking becomes shorter and the quantity of milk it yields decreases.

If preparation is unsatisfactory, post-milking has an important complementary role from the point of view of milk yield.

The length of idle milking time depended in both cases on how the milking technology was put into effect, and was an important factor in the occurrence of mastitis.

More than 50 seconds of idle milking before or after post-milking has a deleterious effect on the health of the udder. This always occurs when the milker is occupied with other cows and is unable to return in time to complete milking.

When using machines which automatically switch over to a lower vacuum after the main phase of milking, the number of mastitis cases did not decrease, but even increased in some farms. According to the investigations, the reason for this is the milkers' "faith" in automatic machinery. They do not think it is urgent to return to cows waiting for post-milking.

Idle milking following mechanical post-milking is also very harmful. This occurs when the milker recommences milking but does not complete post-milking before turning to another cow.

The time between the main phase of milking and the beginning of post-milking for various milkers and different milking sessions ranged from 11 to 187 seconds.

When several milkings of the same cow were examined, the greatest difference in the time which passed before the milker returned was 17 and 187 seconds.

The average time of idle milking during post-milking ranged between 75 and 105 seconds per cow.

These data show that no relationship could be observed between the manner of post-milking and the milkers' familiarity with the milking technology out; chance prevailed in the cases examined.

All in all, post-milking should not be entrusted to milkers, but automatic machines which insert a pause do not endure that it is properly carried out either.

Post-milking, the last phase of milking, must be automatized, taking into consideration the physiological characteristics.

Effect of idle milking after post-milking

Milkers who have started post-milking in one milking platform are often compelled to return to another cow. Therefore, it frequently happens that the milking machine continues to operate after post-milking has ended.

Cases when idle milking lasted longer than 100 seconds occurred with an average frequency of 32%.

Idle milking harmful to the health of the udder must be eliminated by automatization based on new principles.

Effect of omitting post-milking

Owing to the difficulties encountered in carrying out mechanical post-milking, the obvious solution seemed to be to omit this operation. Attempts were made to give theoretical support to this simplified milking technology.

One of the reasons given was that the amount of milk obtained by post-milking could be extracted at the next milking, and that the cows would become accustomed to this situation.

The omission of post-milking is harmful in many respects; since the udder is not emptied, an antilactogenic effect is produced and the reduced oxytocin mobilization leads to a decrease in the effect of prolactin.

According to the current investigations, even with an adequate milking technology the quantity of milk produced was smaller without post-milking, so the lactation result decreased.

Since the milk which was not removed of the end of milking had a higher butterfat content, there was a loss in butterfat.

Experiments on post-milking starting immediately after the main phase of milking were carried out with 6 milkers and 320 cows. The result was an average 7.1% milk surplus. Twenty per cent of the stock examined gave an average milk surplus of 17%. The butterfat surplus averaged 12.5% due to the higher fat percentage.

It can thus be established that the omission of post-milking has a deleterious effect; on the other hand, when it is carried out, idle milking preceding and following it may endanger the health of the udder.

An automat has been elaborated which pulls the udder several times a few seconds after the main phase of milking and continues milking; then once the udder is empty, it removes the milking apparatus. This method is called "single-course" milking. The results are shown in Fig. 1.

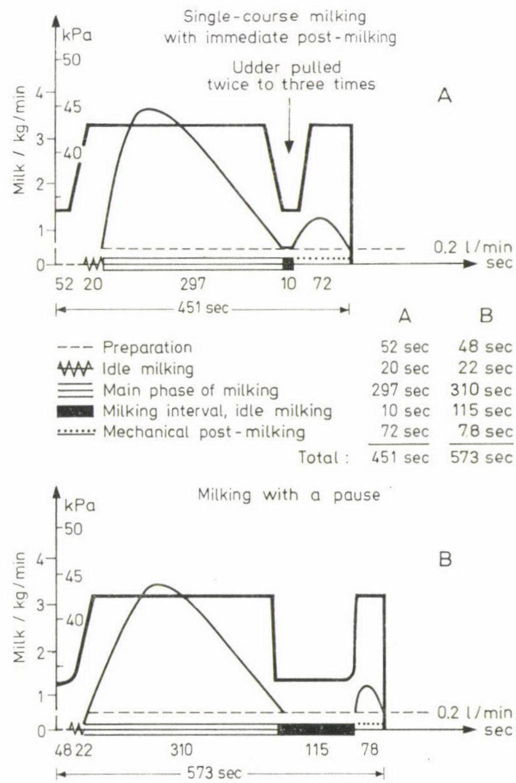

Fig. 1. Results of two automated milking methods

A comparison between mechanical milking with the insertion of a pause and "single-course" automated milking showed that cows from the latter group spent 18.8–35.1% less time on the milking platform, which means that the capacity of the milking unit can be uncreased by 10–20% and the wagebill decreased.

"Single-course" milking in a reduced time with automated post-milking spares the udder, with a consequent reduction in the exogenous factors that make the cows susceptible to mastitis.

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Acta Agronomica Hungarica, 37 (1–2), pp. 161–171 (1988)

ESTABLISHMENT OF SYNTHETIC FEMALE SHEEP LINES IN HUNGARY*

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(Received: 5 September 1986)

Review of the Literature

Since the 1960s researcher have shown ever-increasing interest in prolific breeds. In 1962, researchers in Edinburgh bought Finnish sheep and by 1976 Finnish types were already being bred, or breeding was beginning, in thirty countries (Maijala and Österberg 1977). The first import of Romanovs into France was initiated by Poly in 1963 (Ricordeau et al. 1976). Later, in 1969 the initiation of cross-breeding experiments was witnessed in Hungary (Veress and Stósz 1975) and from 1971 in Czechoslovakia (Jakubec and Krizek 1975). These were followed by a wide range of work done in Spain (Espejo Diaz et al. 1976, Walls Ortiz et al. 1976).

A thorough theoretical justification of the expected biological and economic advantages of cross-breeding was provided by Dickerson (1970). The expected biological increase does not, however, always prove to bet the best from an economic point of view. The intersection of these two factors gives the most advantageous situation. This was first determined by Moay (1966) and was called "profit heterosis".

Comparisons of the Finnish and Romanov breeds both of which are now well known were conducted simultaneously by Jakubec and Krizek (1975) and Veress and Stócz (1975). These studies showed that the Romanov type became acclimatized better that the Finnish. Its performance was even better than it had been in its native territory. These results were confirmed at a national conference in France in 1975 (Brunel et al. 1975, Ricordeau et al. 1976). Inspection of the meat quality of the lambs produced by breeding prolific lines showed that the amount of abdominal suet increased and there was a big drop in quality (Nitter 1975, Jakubec 1977).

A few examples of the synthetic crossing of the two breeds will be presented here without giving and exhaustive account. The development of a so-called "ABRO female line", in which the researchers tried to achieve a mixture of the good qualities of four breeds using the following proportions:

* Lecture held at the 37th "Annual Meeting of the European Association for Animal Production", 1–6 September 1986. Budapest, Hungary.

47% Finnish, 24% East-Friesian, 17% Border Leicester and 12% Dorsethorn, was reported from Edinburgh (Smith et al. 1970). Owen (1976) collected a number of prolific ewes from various breeds and incorporated a 25% proportion of Finnish blood into this nucleus population. This breed has since spread rapidly throughout England and Ireland. Experiments on the crossing of the Gallway and Finnish breeds and the resultant new breed were described by Hanrahan (1974). In a similar way, the INRA female line was developed from 50% Berrichon du cher and 50% Romanov blood (Tchamitchian et al. 1978). This breed is suitable for modern sheep raising for slaughter or for further breeding.

Results in Hungary: Tetra Line Improvement and Crossing

In 1969 R. Burgert, the general director of the Agricultural Complex in Bábolna, purchased twenty different breeds of sheep with the intention of developing a prolific breed suitable for use in modern farming situations. The so-called "TETRA female line" was developed from twenty thousand Merino ewes which were pre-tested Romanovs from three lines and two Finnish of lines.

Important characteristics of the new breed

	Females	Males
Mature body mass (kg)	55– 65	70– 80
Wool production with twice-yearly shearing (kg)	3– 4	4– 5
Lambing rate (%)	200	
Number of lambs per year per ewe	3– 3.5	
Lambs Daily weight gain of up till weaning (g)		
up to day 49	250–270	280–300
day 50–120	200–220	260–280
day 121–300	100–120	120–150

This is a hardy animal with fine white wool and its fleece contains some over-hair; that is to say, the wool quality if carpet. The animals can be bred at 9–10 months and will produce offspring for 6–7 years; 20–23 young can be produced in 10–11 lambings. The type, which consists of about twenty thousand ewes, possesses outstanding breeding properties; it will mate year-round is with lamb again soon after weaning and gives more than ample milk. In order to achieve these characteristics the necessary energy, protein, minerals and vitamins have to be provided, especially during critical periods, i.e. while the ewes are in heat, during early and late pregnancy, and during the suckling

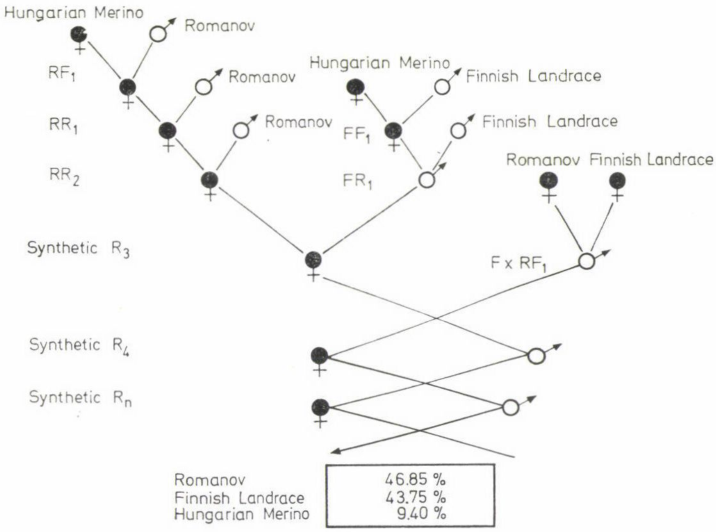

Fig. 1. The scheme of tetra synthetic dame line produced by the Agricultural Complex, Bábolna

period. This was shown in detail by Robinson et al. (1983). The Bábolna Agricultural Complex also has a male line of the Ile de France breed. F_1 ewes in heat can be used for breeding as necessary and can be used with the prolific rapidly growing TETRA-Suffolk as the terminal partner to give high quality production.

Prolific Merino

The offspring of several F_1 stocks of Hungarian Merino ewes bred with Romanov rams were examined. The "A" breeding programme took place at what could be considered as an average cooperative farm on the Great Hungarian Plain; the "B" programme was carried out on a state farm in the German Democratic Republic; and the "C" breeding programme took place on a state sheep-breeding farm (Table 1). The difference in the lambing rates can be attributed, at least inpart, to the fact that in the German study all offspring born alive were counted, whereas in the Hungarian studies only lambs that lived for more than forty-eight hours were included. In the "C" programme, the ewes were mated only once a year, but in the "A" and "B" programmes mating took place more often. Thus, the genetically prolific characteristics of the Romanov were not always utilized.

The high reproductive ability of the F_1 ewes led to an attempt to use a reduced proportion of Romanov blood for the achievement of a Merino having the reproductive characteristics of the Romanov but with fine wool. Unlike the usual breeding practice in Hungary, selection was carried out not for meat

Table 1

Performance data for Romanov × Hungarian Merino F_1 ewes in different stocks

Years	Stocks	Number of ewes	Lambings	Lambs born	Lambings ewe/year	Prolificacy rate	Lambs born ewe/year
	A	437	539	779	1.233	144.5	1.782
1975	B	—	—	—	—	—	—
	C	132	85	128	0.644	150.6	0.969
	A	430	407	640	0.947	157.2	1.488
1976	B	47	36	67	0.766	186.1	1.425
	C	102	77	127	0.755	164.9	1.245
	A	371	510	907	1.375	177.8	1.375
1977	B	39	66	162	1.692	245.5	4.154
	C	59	46	72	0.779	156.5	1.220
	A	308	323	613	1.049	189.8	1.990
1978	B	33	28	70	0.848	250.0	2.121
	C	45	40	66	0.889	165.0	1.466
	A	259	337	616	1.301	182.8	2.378
1979	B	29	50	131	1.724	262.0	4.517
	C	105	71	124	0.676	174.6	1.181
	A	1805	2116	3555	1.172	168.0	1.969
1975/79	B	148	180	430	1.216	238.9	2.905
	C	443	319	517	0.720	162.0	1.167
Σ x, or $\bar{x}$		2396	2615	4502	1.091	172.2	1.181

A = Hungarian Cooperative Farm; B = State Farm in Germany; C = Central Testing Station

and wool production, but for reproductive capacity (Veress 1980). The new breed will be called Prolific Merino. The scheme of the breeding process in presented in Fig. 2. The first test for R_1 ewe population typing took place at the site of breeding programme "C". As a control, middle-aged Merino ewes were used which had lambed twins for three consecutive years. The Prolific

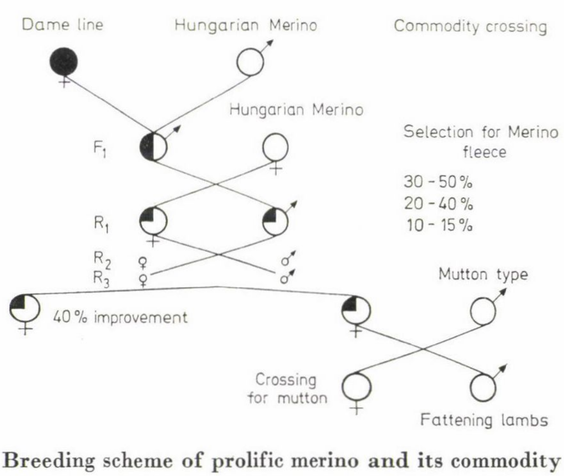

Fig. 2. **Breeding scheme of prolific merino and its commodity crossing**

Table 2

Performance data for Hungarian Merino (HM) and Prolific Merino (PM) ewes
(Stock C)

Years	Genotype	n	Number of lambings	Lambs born	Lambs weaned	Lambings ewe/year	Fecundity rate	Lambs born ewe/year	Lambs weaned ewe/year
1979	HM	286	219	310	263	0.766	141.6	1.084	0.919
	PM	98	72	111	96	0.735	154.2	1.133	0.979
1980	HM	199	182	283	250	0.915	155.5	1.422	1.256
	PM	71	68	104	96	0.958	153.0	1.465	1.352
Σ x or $\bar{x}$	HM	485	401	593	513	0.827	147.9	1.223	1.058
	PM	169	140	215	192	0.828	153.6	1.272	1.136
						+0.001	+ 5.7	+0.049	+0.078

Table 3

Performance data for Merino and Prolific Merino first-gravid ewes used in a grass utilization experiment
(Stock D in year 1975)

	HM	PM	Index
Number of ewes	58	58	—
Number of lambings	67	107	159
Lambs born	71	145	204
Lambs weaned	66	117	177
Lambings ewe/year	1155	1844	160
Prolificacy rate	105.9	135.5	128
Lambs born ewe/year	1224	2500	204
Lambs weaned ewe/year	1138	2017	177

Table 4

Performance data for Merino and Prolific Merino ewes
(Stock E in years 1981–1985)

	HM	MM	PM	HM/PM, %
Number of ewes on 1 January 1981, n	907	670	126	—
Selection rate/year, %	27.6	23.6	18.6	—
Hogget reproduction rate, %	26.0	11.4	18.0	—
Fertility rate, %	86.2	56.6	96.7	+12
Barrennes rate, %	22.42	23.00	19.97	−11
Prolificacy rate, %	153.7	135.9	155.1	+ 1
Lambs born/year/ewe, No.	1.32	0.77	1.50	+13.6
Ewe live mass, kg	56.0	59.0	50.0	−10.0
Ewe fleece mass, kg	5.73	5.87	4.58	−20.0
Relative fleece production,* %	10.23	9.95	9.07	−11.0

* Fleece mass $\times$ 110 : live mass

Table 5

Performance data for Hungarian Merino and Prolific Merino lambs from birth to weanaing
(Stock C in year 1979–80)

		Birth mass/kg		Suckling in days	Average daily mass gain/g		
		n	$\bar{x}$		n	$\bar{x}$	Index
Male single	PM	61	4.66	72	283	211	100
	HM	30	3.72	82	55	238	113
Female single	PM	67	4.41	102	704	198	100
	HM	42	3.80	78	80	217	110
Male twins	PM	119	3.89	74	210	171	100
	HM	86	3.05	83	300	219	128
Female twins	PM	110	3.78	93	420	180	100
	HM	76	3.10	85	249	192	107

Merinos in the same herds were first- or second-gravid ewes (Table 2). The results show that the tested animals were slightly more prolific than the controls, but in all three stocks the results were higher than the national average. At the experimental grounds of our University, Hungarian Merinos and Prolific Merinos of the same age were bred more than once per year. Under these better biological conditions, the improved genetic make-up of the breed was better revealed (Table 3). From the typing-test station the stock of Prolific Merino was taken to a state farm, where the results from five consecutive years were compared with those of a meat-producing stock from the German Democratic Republic (Table 4). In the given environment the Hungarian Merino performed best, as the conditions were much worse than those required

Table 6

Performance data

Genotype	Hungarian merino		Prolific merino	
Year	1977*		1977**	
Sex	male	female	male	female
Number of lambs, n	782	45	15	15
Age at beginning of fattening, day	71	77	62	68
Average body mass at start of fattening, kg	19.6	20.2	16.4	16.5
Fattening days, day	60	61	59	59
Average body mass at end of fattening, kg	36.4	33.4	33.7	28.7
Average daily mass gain, g	281	200	294	207
Average daily concentrate intake, kg	1.19	1.12	1.11	0.91
Feed conversion rate, kg/kg	4.22	5.60	3.78	4.04
Slaughtering, %	46.1	51.5	47.4	47.4

* Central Fattening Station
** in Stock A

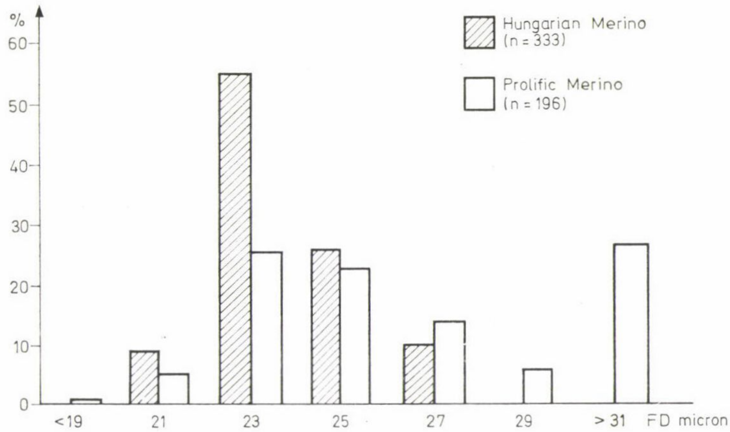

Fig. 3. Distribution of fiber diameter (FD) in the wool of two merino types

by either the breeding or the meat-producing stock. It was apparent, however, that the fertility rate of the breeding stock is much higher.

In stock breeding "C" the mass gaine of Hungarian Merino and Prolific Merino lambs during suckling were compared for two consecutive years (Table 5). The mass increase for Prolific Merino lambs was 7–28% higher, indicating that the Prolific ewes gives more milk. When comparing the rate of fattening after weaning, the breeding stock did at least as well as the Hungarian Merinos (Table 6). Gives early weaning and quick fattening, the ewe lambs and young at ± age of 100 days or 125 days, respectively. This is due to an increase in the suet content. Samples of the meat of Prolific Merino showed a higher pigment content than that of Hungarian Merinos (Veress 1985).

for fattening lambs

Prolific merino		Hungarian merino		Prolific merino			
1979**		1980***		1980***		1980/81****	
male	female	male	female	male	female	male	female
21	26	33	45	36	40	30	30
70	68	73	78	70	71	52	48
17.5	16.8	17.8	18.9	17.8	16.7	15.9	15.4
60	60	59	54	61	61	78	78
35.6	29.5	35.9	31.2	33.8	28.5	39.2	32.1
302	212	307	227	265	194	258	196
1.13	0.98	1.20	1.19	1.25	1.10	1.22	
3.75	4.28	3.91	5.23	4.76	5.68	4.76	4.95
—	—	—	—	—	—	49.8	49.2

*** in Stock C
**** in Stock D

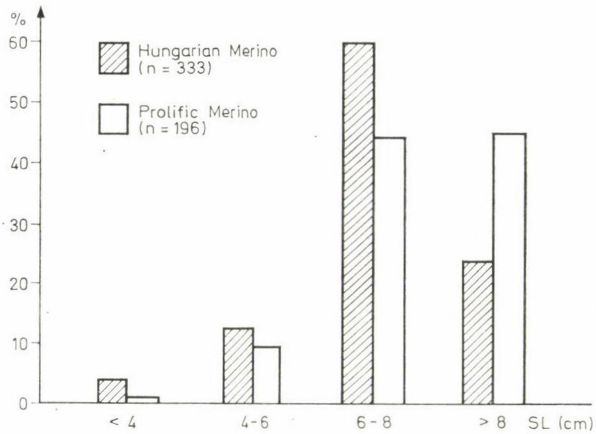

Fig. 4. Distribution of staple length (Sl)

The distribution of lambs from the R_1 construction is shown in Fig. 3. The frequency of crossbred quality wool in the Prolific Merino was 31.2%. Considering the length of the fleece, however, the incorporation of Romanov blood into the line was definitely advantageous, as an average length of eight-centimetres was found twice as often as in the controls (Fig. 4).

J-AKI-1 and J-AKI-2 dam lines

Mihálka et al. (1983) started indirect 3- and 4-race crosses, where Hungarian Merino ewes were first crossed with Swedish Landrace rams, after which the F_1s were crossed with Finnish Landrace rams (Fig. 5). Both the F_1 Hun-

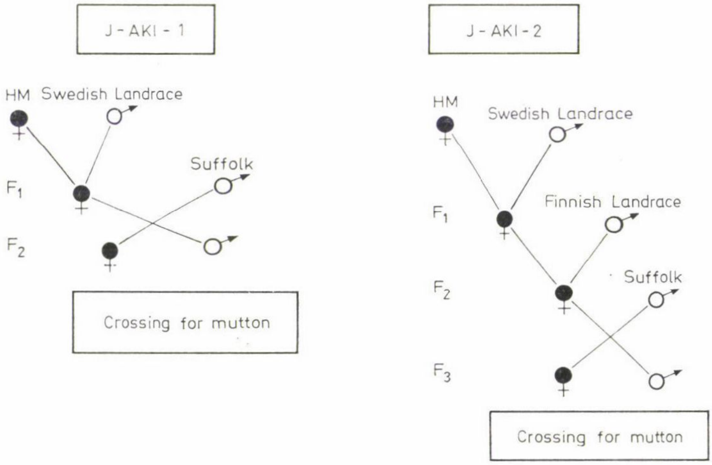

Fig. 5. Breeding scheme for commodity crossing

Table 7

Performance data for J-AKI crossbred ewes

Genotype	n	Lambings/year	Lambs born ewe/year	Lambs weaned ewe/year
Hungarian Merino	207	0.80	1.09	0.93
J-AKI-1	170	0.96	1.66	1.30
J-AKI-2	64	1.08	1.69	1.32

Table 8

Performance data for J-AKI crossbred lambs from birth to the end of fattening

Genotype	Sex	ns	Daily mass gain to 120 days		Slaughzer-ing, %	Bony mutton/day	
			g	%		g	%
Hungarian Merino	male	166	240.1	100	44.63	122.1	100
J-AKI-1 dam line	male	82	201.9	84	48.08***	94.1	77
J-AKI-2 dam line	male	63	240.2	100	44.58 ns	120.8	99
J-AKI-1 dam line × Suffolk	male	83	265.6	111	50.11***	148.4	121
J-AKI-1 dam line × Suffolk	female	82	256.4	107	50.08***	132.2	108
J-AKI-2 dam line × Suffolk	male	18	253.0	105	50.80***	135.8	111
J-AKI-2 dam line × Suffolk	female	17	215	89	51.00***	127.0	104

ns = not significant
*** = $P < 0.1\%$

garian Merino ewes that were mated with Swedish Landrace rams and their F_2 daughters, sired by Swedish Landrace rams, could be used as terminal partners in crosses with Suffolk rams.

The greasy fleece weight of F_1 ewes decreased by 0.7 kg and their fibre diameter deteriorated by 1's, but their fertility rates and reproductive abilities improved considerably (Table 7). Although the mutton yield of male lambs from dam lines is lower than that of the Hungarian Merino, the weight gain of lambs descending from Suffolk crosses is better and the bony mutton production per day is considerably higher (Table 8).

Conclusions

From the initial Finnish and Romanov cross-breeding, lambs homozygous for white colour are produced. Both breeds are equally suitable for breeding with good characteristics in the ewes for cross-breeding. They can be used on modern farms to breed lambs for slaughter.

The greater the proportion of Romanov or Finnish blood in the cross-breeding, the larger the offspring, but they also require better conditions for feeding and raising.

The so-called "ewe characteristics" of the Rambouillet Merino can be considerably improved by the introduction of 25% Romanov blood and this can be done without spoiling the wool-producing character of the Merino. This population, with its smaller body size, can be used more economically by sheep grazers in Hungary.

Acknowledgements

The author expresses his thanks to R. Burgert, Director, and J. Tóth, Deputy Director, for the data on the Bábolna TETRA programme; to T. Mihálka and co-workers for the data on the J-AKI programme and finally to J. Stócz, L. Radnai and L. Lovas for their assistance in gathering data on the Romanov crosses.

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Acta Agronomica Hungarica, 37 (1–2), pp. 173–182 (1988)

IMPROVEMENT OF MERINO SHEEP FOR PROLIFICACY*

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(Received: 5 September 1986)

Introduction

After the end of the 18th century most of the profit on European farming estates came from the breeding of fine woolled sheep (Gaál and Gunst 1977). From the middle of the 19th century onwards the very fine woolled animals were gradually replaced by animals with stronger, heavier fleeces, e.g. Rambouillet. From the beginning of the 20th century these animals were displaced to some extent as the direction changed towards the breeding of mutton Merinos. After World War I the Rambouillet type remained popular in Hungary as a milking sheep and was also popular due to its ability to lamb frequently (Baskay 1936, Schandl 1936). The family of multiple-use Merinos gained a new member at the end of this century.

The Booroola Merino, which can be regarded as a completely different strain of Merino, was first reported two decades ago (Turner 1966) and the high fecundity of the strain and its crosses has been identified as being under the control of a single gene (Piper et al. 1982, Davis et al. 1981, 1982). This strain also has a longer breeding season than other Merinos (Bindon 1984). The discovery of a single gene which controlled fecundity in the Booroola caused a sensation in animal breeding throughout the world. With the exception of the N gene associated with hairy fleeces and horn growth in Romney sheep (Dry 1955), single gene effects in animal production have been of little productive significance.

Detailed studies in New Zealand with many breed types and crosses have shown that in comparison with "local breed" ewes FF and F+ animals will have a superior reproductive performance of approximately:

Ovulation rate	FF	+3.0	F+	+1.5
Litter size	FF	+1.5	F+	+1.0

*37th Annual Meeting of the European Association for Animal Production", Budapest, Hungary, 1–6 September 1986.

The Booroola or F gene therefore offers considerable possibilities for increasing total production in a sheep industry in crisis (Elsen and Ortovant 1984).

In Hungary the Negretti, Electoral Negretti and Rambouillet strains became more common from the 18th century onwards, and since 1970 the Mutton Merino type has been used to improve bodyweight and muscularity. Today 95–98% of Hungarian sheep are Merinos, so any breed improvement programmes should logically be associated with this breed. The first Booroolas were imported from Haldon Station in New Zealand with the assistance of the Invermay Agricultural Research Station of the NZ Ministry of Agriculture and Fisheries in 1980, with a further group arriving in 1982. Three rams were imported for experimental purposes in 1983 and six in 1984. The Society for Breeding and Improving the Booroola was formed in Hungary in 1985, and in 1986 a further 13 rams and six ewes were imported for the Society from James Innes of Haldon Station in New Zealand.

The total available stock consists of individuals descended from eight ram lines from 14 different fathers. Eight of the animals are the result of interbreeding high quality ancestor to different degrees (F_x = 9.3–25.0%) Nathusius's warning must not be ignored ... "interbreeding in the hands of the average livestock breeder is like a razon in the hands of a monkey ...". This risk has consciously been taken, and pre-planned pairings of relatives have also been carried out for some rams.

The aim of cross-breeding programmes

In Hungary the aim of the crossing programmes is to mate homozygous Booroola rams with local Merino ewes to produce F_1 animals which carry the F gene. These ewes when mated with a mutton-type variety, should achieve fecundity levels of up to 200% each lambing. It is of course important to ensure that the F_1 ewes are adequately fed, so that they have the opportunity to express their genetic potential, and so that lambs from multiple births are of sufficient birthweight to maximize chances of survival.

It has been assumed that the relative fleece weight and fibre diameter would be more favourable in the F_1 ewes than in Hungarian Merinos. Detailed observations of fleece growth and the characteristics of various crosses will be made throughout the experimental programmes. The use of the Booroola in crossing programmes with the Hungarian Merino will significantly increase the number of lambs born and the total meat production by using a terminal mutton race to make up at least 20% of the genetic background (Veress 1983).

The Society for Breeding and Improving the Booroola aims at producing homozygous nucleus flocks (FF) on various stocking farms. This will be possible using techniques for the identification of animals carrying the F gene, and programmes of back-crossing to the desired breed type, or interbreeding of crosses, to increase the gene frequency in a desired breed type. In this way it should be possible to provide suitable FF rams for the various sectors of the Hungarian sheep industry. Rams of mutton type to be used in commodity crossing should also be produced by the Society (Fig. 1).

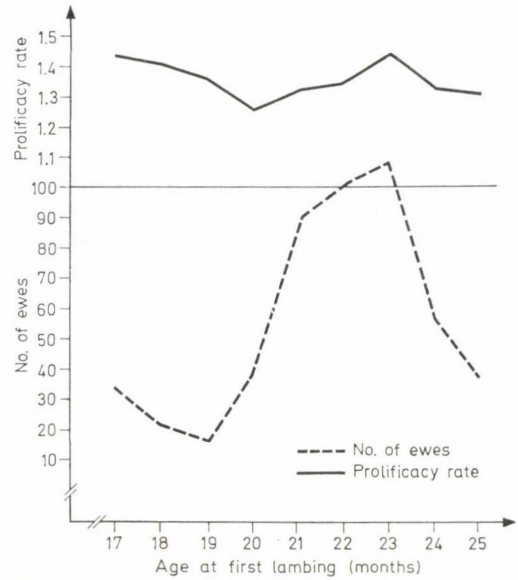

Fig. 1. Scheme of herd improvement and commodity crossing

Booroola cross-animals have been under some criticism in Australia and New Zealand, and also in other sheep breeding countries such as Hungary due to the slower initial growth rate and smaller body size. Consequently in some breeding flocks in France (Elsen and Ortavant 1984) and also in Hungary, programmes are being implemented where the Booroola gene is being contrasted in different breed types by picking out homozygotes originating from the interbreeding of F_1 animals. This strategy has already been undertaken in Romney, Coopworth and Corriedale flocks in New Zealand (Davis et al. 1980, Davis and Kelly 1983).

If Hungarian Merino rams are mated with the first cross F+ ewes, then the progeny will be 3/4 Hungarian Merino 1/4 Booroola, and again the F gene carriers can be identified by laparoscopy or by lambing records.

Results of cross-breeding programmes implemented since 1982

Several large sheep farms Hungary have cooperated in Booroola crossing programmes since 1982 on the basis that rams must be retained on those farms. Therefore, ewes have been mated by artificial insemination with semen col-

Table 1

Fertility of Hungarian Merino ewes inseminated with Booroola semen transported to farms

Flock	Date of insemination	No. of inseminated ewes	% of ewes lambing	Litter size
A	Dec. 1982/Jan. 1983	1202	39.9	1.06
B	May/June 1982	1443	34.9	1.18
C	July/Aug. 1982	274	9.1	1.16
D	Sept./Oct. 1982	966	33.1	1.36
A	Nov./Dec. 1982	2143	67.8	1.16
B	Jan./Feb. 1983	864	13.2	1.11
		6892	42.0	1.16

Table 2

Development of livemass in Booroola cross-bred and Hungarian Merino contemporary lambs "D" Flock 1982

	n	Livermass		
		Birthmass	30 days	100 days
Male single				
Booroola F_1 rams	93	4.02	10.82	22.60
HM rams	51	4.16	11.60	25.67
% Difference		−3.4**	−6.3**	−12.0**
Male twins				
Booroola F_1 rams	91	3.66	9.31	22.03
HM rams	40	3.84	9.86	25.03
% Difference		−4.7***	−5.6*	−12.0***
Female single				
Booroola F_1 ewes	98	3.88	10.50	20.89
HM ewes	53	4.00	11.24	23.07
% Difference		−3.0***	−6.6**	− 9.4***
Female twins				
Booroola F_1 ewes	76	3.56	9.05	20.65
HM ewes	45	3.70	9.49	22.07
% Difference		−3.8***	−4.6 ns	− 6.4**

* $P < 5\%$; ** $P < 1\%$; *** $P < 0.1\%$
ns = non significant

Table 3

Development of livemass in Booroola cross-bred and Hungarian Merino contemporary lambs "A" Flock 1983

	n	Livemass		
		Birthmass	30 days	100 days
Male single				
Booroola F_1 rams	73	3.62	11.03	27.81
HM rams	22	3.92	11.91	32.00
% Difference		− 7.7*	− 7.4*	−15.0***
Male twins				
Booroola F_1 rams	36	2.90	8.88	22.01
HM rams	23	3.26	10.04	30.05
% Difference		−11.0***	−12.0***	−26.8***
Female single				
Booroola F_1 ewes	63	3.40	10.65	24.08
HM ewes	24	3.23	9.84	25.63
% Difference		− 5.2 ns	+ 1.0 ns	− 6.1*
Female twins				
Booroola F_1 ewes	36	2.81	8.63	20.01
HM ewes	13	2.95	9.32	26.54
% Difference		− 4.8 ns	− 7.5*	−24.6***

* P < 5%; ** P < 1%; *** P < 0.1%
ns = non significant

lected within 12 hours or less. Oestrus was detected twice a day at 700 and 1500 hours and inseminations were carried out afterwards. Ewes were inseminated with 0.1–0.2 ml of semen diluted 1 : 1 with Micovanov, the inseminate containing not less than 80×10^6 spermatozoa.

The results of inseminations carried out on four farms are presented in Table 1.

The results of the insemination depended on the distance between the farms and on the seasons. The rams were placed at sheep-farm *A*, which is situated 20 km from farms *C* and *D*, but 120 km from farm *B*; consequently the insemination took place 8 hours later on the latter farm.

Therefore farms *B* and *D* wished the rams to be placed there, because they wanted to do the insemination locally.

Farms *A* and *D* have excellent quality breeding flocks where the birth-weights of the lambs and weights at 30 and 100 days were recorded. These were compared with contemporary progeny of Hungarian Merino (HM) ewes from HM sires. As the data from both farms are similar only those from farm *D* are presented here. The data in Tables 2 and 3 provide a comparison on the

Table 4

Performance data for Booroola cross-bred (F_1) and Hungarian Merino one-year-old breeding ewe lambs and ram lambs

	n	Livemass (kg)	Greasy fleece (kg)	Clean fleece (kg)	Staple length (cm)	Relative wool production	
						Greasy wool	Clean wool
"D" Flock, 1983							
Booroola F_1 hoggets	77	40.31	4.80	—	10.11	11.91	—
HM hoggets	59	42.98	4.86	—	9.36	11.30	—
% Difference		−9.40*	−1.30 ns		+10.80**	+5.40 ns	—
Booroola F_1 rams	120	59.50	7.29	2.99	9.55	12.25	5.02
HM rams	80	64.92	7.59	3.10	8.89	11.69	4.77
% Difference		−8.3***	−4.0*	−3.5 ns	+7.4**	+4.7 ns	+5.2*
"A" Flock, 1984							
Booroola F_1 hoggets	76	40.14	5.49	—	8.72	13.67	—
HM hoggets	100	44.71	6.73	—	8.12	15.05	—
% Difference		−10.2***	−18.4***		+7.4***	−9.2**	—
Booroola F_1 rams	62	61.63	7.46	3.37	10.09	11.91	4.84
HM rams	81	64.49	8.16	3.53	9.70	12.63	4.40
% Difference		−4.5*	−8.6**	−4.5 ns	+9.6***	−4.6*	+10.1***

* $P < 5\%$; ** $P < 1\%$; *** $P < 0.1\%$
ns = non significant

two genotypes in sex and birthrank groups. Progeny from Booroola sires weighed −11–+5% at birth. At 30 and 100 days of age the Booroola cross animals were 4.6–12% and 6.4–24.6% lighter than the HM progeny. Most of these differences were also statistically significant.

In Table 4 the livemass and fleece characteristics of Booroola and HM rams and their F_1 progeny on two farms are compared. Data for single and twin-born animals have been combined in the table. The body masses of the F_1 progeny were approximately 10% less than in the HM animals. There was no significant difference in greasy fleeceweight between the HM and F_1 animals in Flock *D*, although there was a significant difference in Flock *A*. These data are in agreement with earlier reports (Hawker et al. 1980, Elsen and Ortovant 1984).

The staple length was increased in F_4 progeny in comparison with the HM animals (7.4–10.8%) and the advantages of the Booroola crosses in relative wool production were also obvious. An assessment of the wool by experts from the Qualifying Institute for Animal Breeding and Feeding (ATMI) also showed the F_1 animals to be superior for colour and evenness. Wool from farm *B* fetched a 25% higher standard price for the 500 F_4 lambs in comparison with 200 HM lambs of the same age.

As the female F_4 progeny born on farms *A* and *D* did not differ in fertility or prolificacy in comparison with the HM ewes at their first lambing, these farms temporarily suspended their crossing programmes.

Ram No. 8502 was also included in previous comparisons. No determination has been made of whether these rams are FF or F+ but some advantage

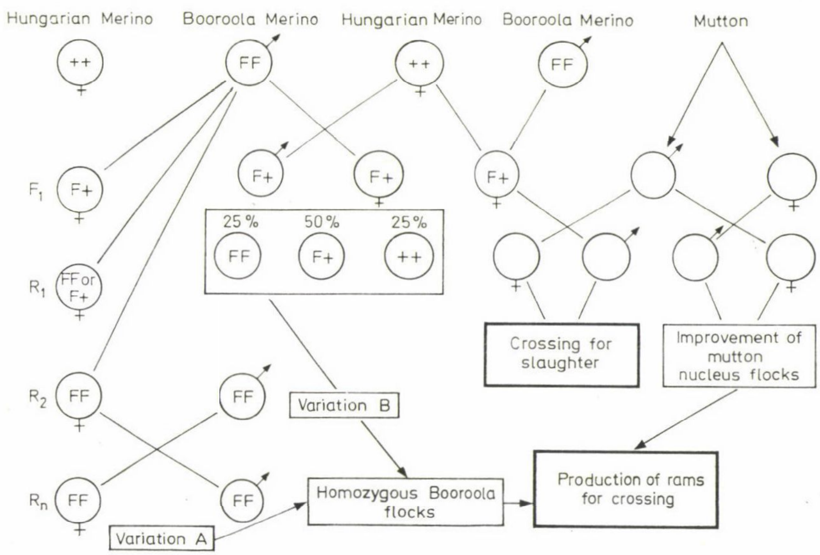

Fig. 2. Relationship between age and reproduction Booroola F_1 ewes at first lambing

Table 5

Reproductive performance of Booroola F_1 and Hungarian Merino ewes at first lambing

Sire	n	Average age at lambing (months)	Mean litter size	Percentage	
				twins	triplets
8502 Imported Booroola	155	21.8	1.32	24.5	3.9
086 Imported Booroola	135	21.6	1.30	22.2	3.7
051 Imported Booroola	211	21.7	1.32	26.1	1.9
All F_1 Booroola Sires	501	21.7	1.32	24.6	3.0
Hungarian Merino	97	21.6	1.11	11.3	—

in fecundity has been passed on to at least some of their progeny. The data suggest the rams used were heterozygous (F+). Fig. 2 clearly indicates that the age at first lambing did not influence the prolificacy of the ewes.

Further breeding tasks in Hungary

With the development of breeding programmes incorporating the Booroola gene in Hungarian flocks it is essential to develop laparoscopy skill to enable detailed recordings to be made of the ovulation rate in control HM animals in comparison with various crosses. The use of this technique (Davis et al. 1982, Davis and Kelly 1982) will enable information on many questions to be collected:

(a) The ovulation rate of the Hungarian Merino animals at different times of the year must be determined, to provide information on more frequent lambing, which is becoming more popular in this country.

(b) Laparoscopy is essential for the examination of groups of daughters from rams in progeny tests in order to determine genetic status, i.e. FF or F+.

(c) Ovulation rate records for females will allow them to be grouped into animals not possessing the F gene (++), heterozygous (F+) and homozygous animals (FF).

(d) Progeny testing investigations are also urgently required for the categorization of newly imported rams, by crossings with HM animals into either F+ or FF genotypes.

Within Hungary there will have to be different priorities in some selection programmes due to the fact that some animals are milked, and also due to the fact that some breeding flocks are expected to lamb approximately every eight months. Progeny testing of rams is a time-consuming process and the programmes presently undertaken in Hungary take 3–3.5 years, by which time some of the rams may well have died. Therefore, efforts are being made to freeze the spermatozoa of valuable animals wherever possible, so that ewes can be fertilised subsequent to progeny tests. However, use of laporoscopy in young ewes should enable the progeny test time for individual rams to be diminished, facilitating their use for mating. It is suggested that progeny tests where 20–30 daughters are laparoscoped to determine ovulation rate two or three times at 18–19 months of age would be an appropriate strategy to adopt.

The strategy of freezing ram semen is also likely to be effective, as Salamon (1985) has introduced spermatozoa which had been frozen for 16 years directly into the uterus and achieved a 60% fertility rate. This is a particularly promising result which should have relevance under Hungarian conditions.

Management factors for increasing sheep production

It is important for the majority of farms to endeavour to induce their sheep to lamb more than once a year (i.e. every eight or nine months) and also, if necessary, to milk the ewes. In order to adopt these strategies, early weaning of the lambs at 30–40 days is important, and, as a consequence, techniques for fattening these early weaned lambs spread quickly in Hungary since 1971 (Veress et al. 1975).

It is also likely that ewes will need higher levels of feeding with energy and protein during the critical periods of the year, i.e. prior to and during mating, late pregnancy and lactation. The required feeding levels are likely to be higher than those specified by the former Hungarian Practice of Merino Breeding.

Attention should also be paid to efficient pasture utilisation during the appropriate seasons, and introduce rotational grazing techniques.

Those lambs which cannot survive in large flocks by suckling from their mothers must be raised artificially in automatic lamb feeding systems.

These systems have previously been specified for Romanov lambs (Veress and Lovas 1980).

In order to determine pregnancy and the number of foetuses being carried, ultrasound instruments should also be available. This would allow the appropriate energy and protein levels to be supplied to ewes bearing multiples. As well as the above factors, which have been identified as necessary within sheep management programmes, there will be a need for improved management expertise during all stages of intensive sheep production systems. Providing these management skills are improved, and providing the technical skills required for the determination of the various Booroola genotypes in both males and females are achieved, there are obvious opportunities for the use of these Booroola animals to expand sheep production in Hungary.

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Acta Agronomica Hungarica, 37 (1-8), pp. 183-189 (1988)

Book review

LAMAROUE CLAUDINE: *Maladies et accidents culturaux du tournesol* (Diseases and damages in sunflower cultivation). Editor: Institut National de la Récherche Agronomique (INRA), Paris, 1985. ISBN: 2-85340-708-X.

This technical book of scholarly character and attractive format, indispensable for those engaged in sunflower cultivation, was published by the INRA in 1985.

The book runs to 119 pages, with 2 tables and 125 illustrations — of which 115 are colour photographs, and the others are drawings. Most of these colour photographs show symptoms of plant damage.

Chapter 1 presents a botanical description of the healthy plant and interprets the related terminology.

Chapter 2. Provides a key for identifying damage observed in the different parts of the plant.

Chapters 3 and *4* show the symtoms of important and less significant bacterial and fungal diseases and the parasites of the sunflower that occur in France, with a discussion of the disorders in the development of the inflorescence.

Chapter 5. Deals with damage caused by animals, mostly birds and rabbits.

Chapter 6. Vividly describes harmful insects and their effect on sunflowers.

Chapter 7 discusses the injuries caused by such climatic factors as wind and hail.

In *Chapters 8* and *9* the symptoms of the phytotoxic effect of pesticides, fertilizers and other chemicals, the symptoms of nutrient deficiency as well as lesions traceable back to genetic causes are described.

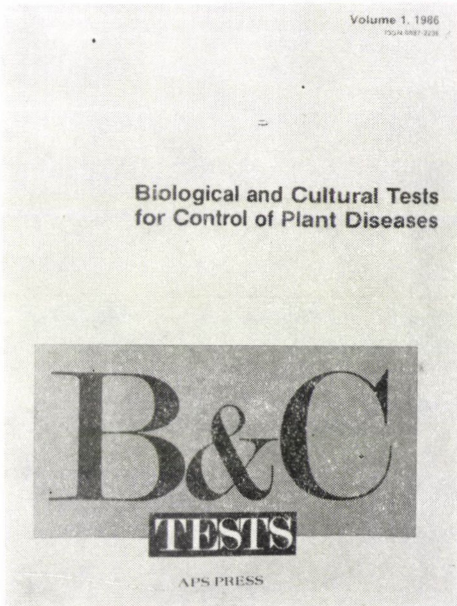
The book finally summarizes the way of life of major pathogenic fungi and the methods of controlling them.

A phytopathological encyclopedia included within the book thoroughly explains the technical terms.

To summarize the book is indispensable for sunflower growers, since it offers help in identifying any disorders observed in the plant and locating their causes. An easy recognition of the symptoms is rendered possible by the large number of colour illustrations.

M. GLITS

HARTMAN, R. J.: *Biological and Cultural Test for Control of Plant Diseases* (B and C Tests) Knob Road, St. Paul, Minnesota 55121. — ISSN 0887-2236.



The American Phytopathological Society (APS) continuously published summaries of its investigation results. The book "*Biological and Cultural Tests for Control of Plant Diseases*" edited in this framework contains the results of experiments carried out in 1985 on plant diseases and nematodes.

The book presents the results of 69 examinations completed, along with indices of authors, host plants and pathogens to assist orientation.

These examination results were obtained with the following plants:

— apple
— bean, cucumber, eggplant, onion, pepper, sweet-pepper, potato, radish, squash, sweet potato, tomato, watermelon, corn, soybean, barley, wheat, cotton, peanut, tobacco
— turfgrasses: *Agrostis*, *Poa*, *Lolium*, *Festuca* species
— *Chrysanthemum*, crabapple, poinsettia, rose
— American elm.

The experiments can be grouped by the following subjects:

— *In vivo* susceptibility of the new plant varieties to the major diseases of the species and to nematodes. The plant varieties include new, commercially produced and coded varieties.
— *In vitro* or *in vivo* action of fungicides and nematocides. (Seed dressing stand spraying.)
— The effect of cultural practices (irrigation, nutrition, time of harvesting) on the diseases.
— Effect of antagonistic micro-organisms on parasitic fungi in the soil.
— Effect of soil treatments by irradiation on parasitic fungi.
— Comparative study of inoculation techniques.

In the above subject groups, the disease susceptibility of plant varieties, and efficiency tests of fungicides and nematocides are mostly described.

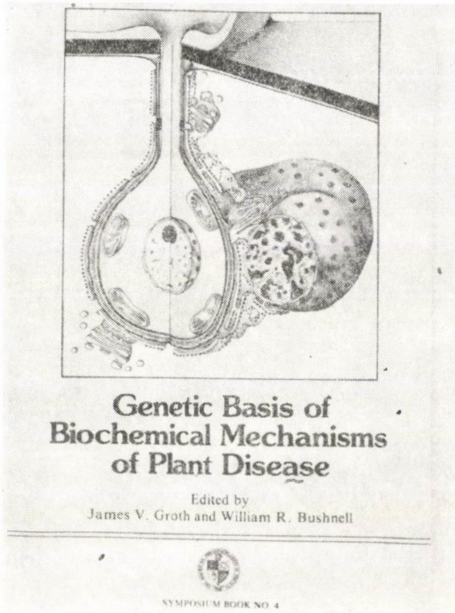
With the examinations, the methods of setting up and evaluating the experiments are also included.

This book is recommended to agriculturists carrying out experiments for plant protection, and to plant breeders as well as to those engaged in variety qualification, who besides making use of these examination results are given methodological guidance in setting up and evaluating the experiments.

M. Glits

Genetic Basis of Biochemical Mechanisms of Plant Disease. (Eds.: J. V. Groth and W. R. Bushnell.) Amer. Phytopathol. Society Press, St. Paul, Minnesota USA. VII + 157 p. 1985.

This book is based on presentations from a symposium held in Guelph, Ontario, in 1984. It has been reproduced directly from



the typewritten manuscripts of the authors. It contains the lectures of five authors on the recognition phenomenon, general resistance, racespecific resistance, non-host resisance, and using trecombinant DNA technology to study the host-parasite interaction.

The paper of W. R. Bushnell on "*The Role of Nonself Recognition in Plant Disease Resistance*" (pp. 1–24) is a speculative summarizing article. The main conclusion is that plants do not possess a general ability to recognize either nonself individuals or nonself species. Recognition is not a component of plant disease resistance. Bushnell believes that plants develop defences only in response to threats encountered in the course of their evolution. In other words, defence responses are more likely triggered by certain substances and activities of attacking microorganisms.

As is known, neither the histocompatibility complex nor the humoral immunological system exist in plants as in higher animals. The occurrence of common antigens (shared proteins) in the pathogen and host seems to help the pathogen species to cause disease in a host species. However these cross-reactions do not relate to specificity at the race or forma specialis levels. We cannot explain why antigenic similarity to a plant host confers an advantage on a parasite.

The author then treats evidences against nonself recognition in plants, such as protoplast fusion, and tissue co-culture with paired species and grafts. After discussing somatic incompatibility in higher plants, he deals with the defence responses triggered by the pathogen. It is known that reactions which lead to disease resistance are controlled by unknown interactions between specific molecules of the host and the parasite. Knowing too little about those specific molecules, one cannot say much at the moment on this mechanism of induced defence.

The second article by Michele C. Heath treats the "*Implications of Nonhost Resistance for Understanding Host-Parasite Interaction*" (pp. 25–42). It would seem that understanding nonhost resistance will help in determining the specific host-parasite interactions. She concludes that plant resistance should be durable if it is multi-component and based on defence mechanisms, also if it is negated by a product of the pathogen with a high degree of specificity. This aıticle, too, seems to be rather speculative.

The next chapter is on "*The Implications of General Resistance for Physiological Investigations*" by B. C. Clifford, T. L. W. Carver and H. W. Roderick. This is the most original contribution to the book. Dealing with rust and powdery mildew diseases, they identified different barriers against fungal development: reduced penetration, prevention of haustorium formation, restriction of haustorium size and efficiency resulting in lower infection frequency, slower colony development and reduced or delayed sporulation. This type of resistance seems race non-specific and governed by complex genetic systems.

The chapter on "*Progress in Understanding the Biochemistry of Race-specific Interactions*" by N. T. Keen deals with recognitions in gene-for-gene systems, the elicitor-suppressor hypothesis, the elicitor-receptor model of resistance connected with phytoalexin production and with the cloning of pathogen avirulence genes. He speculates on the usefulness of recombinant DNA technology which in the future will permit understanding of the relationship between phytoalexin elicitors and pathogen avirulence genes, whether or not they aıe primary (or secondary) avirulence gene products. How do suppressors relate to the function of virulence/avirulence alleles? Are plant resistance gene products the protein receptors for pathogen-produced specific elicitors, as the elicitor-receptor model predicts? According to Keen, it is unlikely that single genes conferring race-specific disease resistance will be useful because they are too specific. It would seem more reasonable to islate a plant gene which confers general, race non-specific, resistance to an entire pathogen species and introduce it into a plant that is susceptible to the pathogen.

The book concludes with A. H. Ellingoe's "*Prospects for Using Recombinant DNA Technology to Study Racespecific Interactions between Host and Parasite*". He believes that recombinant DNA technology already influences plant pathology in the form of diagnostic kits for viruses, by engineered biocontrol agents, by cloned avirulence genes of pathogens and by routine genetic transformation in host plants.

Ellingboe points out that plant breeders and pathologists have manipulated genes for disease resistance for practical gain for more than 75 years, but the products of these genes are still unknown. Genes that control host-parasite specificity will probably soon be cloned in both pathogens and host plants. However, the products of these genes should be discovered in the very near future. Obviously, this information will have great effects on both plant pathology and plant breeding.

The book contains 239 citations and a subject index. This volume certainly will be widely used by students as well as researchers. It contains a great number of new data, new ideas and stimulating speculations.

Z. KIRÁLY

Industrial application of radioisotopes. (Edit. G. Földiák.) Akadémiai Kiadó, Budapest, 1986.

This book provides a comprehensive treatment of the application of isotopes in practically all branches of the industry. Clearly filling a gap in the literature, it reviews the recent developments in this subject. It will thus enable the technical staff working with isotopes and nuclear technology to choose the most appropriate method for solving those problems they confront in their daily work.

The book contains these 8 chapters:
Basic data and definitions
Nuclear instruments and measurements
Radiotracer techniques
Radioanalytical methods
Nuclear borehole geophysics
Radiation technologies
Industrial radiography
Radiation protection (health physics)

To the specialists of the agriculture and food industry I would like to point out the chapters 2, 3 and 6, which deal with such problems as level height measurement, thickness mearuement, moisture content determination, metabolic studies, radiotracer techniques in pesticide research, radiobiological processes in agriculture (radiostimulation, radiomutation), food irradiation, etc.

The uniform treatment of the topics discussed avoids repetition of the material.

Because of its integrated front of discussion, the book will be of value to university staff and students concerned with studies on isotopes and nuclear equipment, in addition to those working with isotopes and radiation techniques in industry, agriculture or governmental establishments.

A. S. Szabó

Peter Friedrich: *Supramolecular enzyme organization* (Pergamon Press, Oxford, Akadémiai Kiadó, Budapest, copyright 1984, reprinted 1986)

In this book the author gives an excellent survey of the results of a relatively new field of biochemistry which has a great future. While in the fifties and sixties, the enzyme chemists devoted their experiments to characterizing the structure and function of single purified enzymes, in the last two decades the research turned toward the interaction of the individual protein molecules their specific associations and their special consequences. The author has a long experience in this field and he treats the problems of the supramolecular organization of the enzymes with great competence.

The book is composed of nine chapters. In *the first two*, the most important questions of the enzyme structures and of the interactions between the side chains and surfaces of the protein molecules are introduced. The *third chapter* gives a detailed survey of the quaternary structure of the enzymes, the oligomeric enzymes and the complex enzymes.

The *fourth chapter* deals with the intermolecular organizations and their functional consequences. In *the next chapter*, the author discusses the multienzyme complexes and multienzyme conjugates, the most simple supramolecular organizations composed of two or more enzymes of different catalytic properties, and the multifunctional proteins which catalyse more consecutive reactions of metabolic path. The experimental results pertaining to the multienzyme complex-conjugates and the interactions of "soluble enzymes" are also summarized here.

The *sixth chapter* sets forth the association of enzymes with cellular structures, the integral membrane enzymes, ribosomal and nuclear enzymes, and the enzymes loosely bound to structures.

The *next two chapters*, "Metabolic compartmentation" and "Current trends in the study of enzyme systems" are presented as special individual reviews of these topics.

The *last chapter* "Enzyme organization: summary and perspectives" is actually not a summary but it discusses some very interesting problems which are connected with enzyme organizations (e.g. "Enzyme organization in disease and ageing", "Enzyme therapy").

This three-hundred-page book is an excellent survey of the subject. It includes 1351 bibliographic references at the end in an alphabetic list.

Although the development is very fast in this field of biochemistry, and the innovations will enrich our knowledge of the individual details, this book will certainly be a very valuable reference during many years to come to enzymologists, biochemists and molecular biologists, for both the researchmen and the graduate students.

L. Boross

Simon, J. E., Chadwick, A. F. and Craker, L. E.: *Herbs*. An Indexed Bibliography 1971–1980. Elsevier Science Publishers, Amsterdam–Oxford–New York–Tokyo, 1984. pp. 770.

The aim of the volume is to provide an easy access to the scientific information in the field of herbs, aromatic and medicinal plants. Though, it is "merely" a bibliography, the 770 pages contain an immense amount of information on selected species, thus spreading scientific data in a relatively concise and informative manner.

It is, however, clear that such a wealth of information cannot be managed without the aid of computer. It is also one of the prizeworthy things about authors that they have been efficient in using the computer for the benefit of scientists and all other interested persons in this field.

In principle, the volume is made up of three parts:

Part 1: *The Herbs*. 64 major herb plants are not merely retrieved but also discussed here in over 100 pages. In each case there is mention of each plant in its Latin, French, German, Italian and Spanish name, its area of distribution and its main botanical features (such as morphology, ecological demands, etc.). There is also useful information on the main active principles, their distribution in the plant, the pharmacological activity and form of application of the drug, its flavouring characteristics, its traditional medicinal uses, including ethnomedicine, and its marketing.

Part 2: *Subject Classifications*. The main body of data is presented in this section, which is devided into the following 10 groups: *Chemistry*, *Botany*, *Bionomics*, *Horticulture*, *Production*, *Ecology*, *Culinary Studies*, *Pharmacology*, *Perfumery*, *Natural Dyes* and *Orna-*

mental Applications, Commerce. Each group is subdivided into numerous subgroups making a clear-cut arrangement of the large amount of information. The references are enumerated in the alphabetical list of first authors.

Part 3: *Other References*, contains extended lists of Books on Herbs, Bibliographies, Reports, Conferences and Symposia and also General References.

All in all, the Indexed Bibliography, 1971–1980, is a store-house of information for professional horticulturalists, chemists, food scientists pharmacologists research students and administrators with an affinity for aromatic and medicinal plants. Though, ab ovo it cannot be complete, still the volume provides an outstanding image of scientific activity in this field, reflecting also some research tendencies of the last decade.

It should also be mentioned that despite the immense amount of data, the volume is easy to handle and well organized When wishing that authors would have the facility and opportunity to compile the second volume for our present decade, I warmly recommend the purchase of this book by interested libraries, and persons.

Á. Máthé

Tersztyánszky, G. and Tóth, Z.: "*A mezőgazdaságilag művelt talajok gyakori rovarlárváinak határozója*" *(Identification book for frequent insect larvae of agriculturally cultived soils)*. Akadémiai Kiadó, Budapest, 1986. 87 pp., 65 figs.

Agro-zoologists during their education obtain information first of all on the morphology of larvae and adults of species that damage aboveground parts of crops. They know much less of larvae living in the soil. These parvae apart from demaging the underground parts of plants promote the decomposition of dead plant; and animal organisms and the development of a favourable soil structure, in brief: they have a share in maintaining the fertility of soil.

The book based upon 25 years of investigations throughout Hungary, describes 36 larvae of *Coleoptera* and 4 larvae of *Diptera*. On further 3 pages, in the socalled Appendix, the Hungarian and Latin names of "the terms of insect morphology found in the text" are given in a lexical form. The date of pupation, the time of appearance of adults, and the latter's method of feeding (phytophage, zoophage, seprophage) are summarized in a table. On the following 43 pages, there are 65 illustrations, 23 of them are larva photos, the other sline drawings of the head nad end of abdomens of the larvae. Only 11 of the 65 figures come from other works, the rest are original drawings by the authors. The drawings indicate the Hungarian names of the taxonomic characters found both on the head and the abdominal section. It was a great help with the nomenclature that two excellent authors, Henrik Steinmann and Lajos Zombori published several books on the morphology of the larval- and insect body in 1981–1984 under the auspices of the Akadémiai Kiadó. The book is made complete by a bibliography containing 17 Hungarian and foreign reference works.

The usefulness of the identification book will be judged first of all by those expert in agroentomology, who will have to decide if soil sterilization or seed dressing with insecticides is necessary.

The book is expected to be of much use for university teachers and students in the course of practical studies on larvae living in the soil. It is similarly indispensable for entomologists engaged in studies of material and energy turnower in agroecosystems.

I think the Akadémiai Kiadó filled a long-felt gap when publishing the authors' book in this simple and fine style.

Gy. Sáringer

Biotechnology in Agriculture and Forestry. Vol. II. Edited by: Bajaj, Y. P. S. Springer-Verlag, Berlin, Heidelberg, New York, Tokyo 1986. pp. 608.

The second volume of the Springer series on Biotechnology in Agriculture and Forestry has been edited by Prof. Bajaj, Y. P. S. a leading personality in the field of plant cell and tissue culture.

The volume is divided into three major sections. Section I comprises contributions on the biotechnology of cereal species, Section II deals with Vegetables, Legumes and Tubers, while Section III is on some future agricultural crops.

The chapters 1–5 provide a survey on various aspects of wheat:

— Biotechnology in wheat improvement,
— Genetic variability through anther culture,
— Improvement through anther culture,
— The production of haploid durum wheat.
— Chapters 6–9 deal with various aspects of rice:
— Regeneration of plants from callus cultures, Factors affecting androgenesis,
— Anther culture for rice improvement in China,
— Cryopreservation of cell cultures.

Relatively few data are available on the important fodder crop maize, a sole chapter on the:
— Production of pure lines through, anther culture. Barley is discussed in two chapters:
— Establishment of cultures and the regeneration of plants, and
— Induction of genetic variability through callus cultures.

A good and comprehensive survey is given of the *in vitro* techniques available in Sorghum and Pearl Millet.

The Section II on Vegetables, Legumes and Tubers is more rich in species. Soybean, *Phaseolus*, Tomato, Pepper, Egg plant, various species of *Cucurbits*, Onion, Garlic and Leek, Celery, Butter-Bur *(Petasites japonicus)*, Potato, Sweet Potato, Sugar Beet, Globe Artichoke are important crops of ours, so that the up-to-date information on their in vitro culturing could be of importance for several researchers and breeders.

Section III deals with the so-called "Future Agricultural Crops". Though according to reviewer the crops *Triticale*, Hordecale, Winged Bean (*Psophocarpus* sp.), *Amaranthus* and Buckwheat represent only a portion of future agricultural crops, the information provided by the section is extremely useful, and up-to-date. It is to be expected that the further volumes planned will cover further species missing from this volume.

Owing to the multiplicity of information, it is impossible to go into detail in evaluating the individual contributions. It should however, be mentioned that the *list of references* attached to each section make the immense amount of information easily available to the reader.

All chapters are pragmatically oriented and most of them include data on culturing, breeding as well as genetic aspects of the species in question. Special importance should be ascribed to the conclusions and prospects, at the end of each chapter. All in all, this latest volume by the Springer-Verlag can be looked upon as a house of Treasures of information for research workers in crop biotechnology, as well as advanced students and teachers of genetics, plant breeding and horticulture, etc. Professor Bajaj and his authors have added an excellent volume to the series providing also an excellent overview of the latest scientific achievements in this field.

Á. MÁTHÉ

ATHERTON, J. G. (ed.): *Manipulation of Flowering*. Butterworths. London–Boston–Durban–Singapore–Sydney–Toronto–Wellington, 1987. pp. 438. Hardcover prices 65 £.

According to traditions the well-designed volume contains the proceedings of the 45th University of Nottingham Easter School in Agricultural Science, held at Sutton Bonington from 7–10 April 1986. The 29 contributions by renowned specialists of this field are arranged in the following 8 sections:

I. Introduction; II. Measurement and prediction of flowering; III. Juvenility; IV. Vernalization; V. Photoperiodic induction and evocation to flower; VI. Photosynthesis, translocation and flower initiation; VII. Flower development; VIII. The future.

W. W. Schwabe's *introductory* contribution on the flowering problem is followed by papers on the *measurement and prediction of flowering* in annual crops (by E. H. Roberts and Summerfield, R. J.) and in clonal plants (by Davy, A. J.). Thornley, J. H. M. draws up a promising model for flower initiation, though it is relevant that still further research is to be done in order to explore the full rang of options involved in the regulation of flowering.

In the ensuing chapter on *Juvenility* and cell determination, Wareing, P. F. presents evidence on the phase-change in plants leading to flowering. Hackett, W. P., Cordero, R. E. and Srinivasan, C. discuss the Apical meristem characteristics and activity in relation to juvenility in *Hedera*, a species with marked morphological differences between the juvenile and mature phases of development. By comparing *Helianthus* sp., *Zea mays* and other dycots, Jegla, D. E. and Sussex, I. M. throws light on the functioning of the apical meristem. In their paper on Floral Determination: A Critical Process in Meristem Ontogeny, McDaniel, C. N., Gebhardt, J. S., Singer, S. R. and Dennin, K. A. come to the conclusion that in shoot meristems goups of cells exist in a unique, sometimes reversible state of development. Their stability is a function of the genotype.

The section *Vernalization* is introduced by a comprehensive review under the title Vernalization — Environmental and Genetic Regulation (by Napp-Zinn, K.). The next papers are more pragmatically oriented: Curd initiation in the cauliflower (*Brassica oleracea* var. *Botrytis* L.) — by Atherton, J. G., Hand, D. J. and Williams, C. A.; Characters related to the vernalization requirement of sugar beet — by Lexander, K.; Vernalization in wheat — by Krekule, J.; Vernalization in the onion — a quantitative approach — by Brewster, J. L.

Section V is introduced by A. R. Rees' review on *Environmental and genetic regulation of photoperiodism*, a paper that also calls attention to the utmost complexity and volume of information that makes it impossible to attempt any synthesis of environmental and genetic regulation of photoperiodism. The subsequent contributions by prominent representatives of the research on flowering discuss various, but important facets of photoperiodic induction and evocation to flower. Thus, Effects of illuminance on flowering in long- and shortday grain legumes (by Summerfield, R. J. and Roberts, E. H.); The genetic control of day-length response in wheat (by Law, C. N.); Photoperiodic process: induction, translocation and initiation (by Deitzer, G. F.); Inductive events in the leaves: time measurement and photoperception in the short-day plant, *Pharbitis nil* (Vince-Prue, D.); Photoperiodic induction and the floral stimulus in *Perilla* (by Zeevaart, J. A. D.); A new strategy for the identification of native plant photoperiodically regulated flowering substances (by Jaffe, M. J., Bridle, K. A. and Kopcewicz, J.); Effects of light on cell division in the shoot meristem during floral evocation (by Francis, D.); Initiation and growth of internodes and stem and flower frusta in Silene coeli-rosa (by Lyndon, R. F.).

Section VI focuses mainly on the *metabolic preconditions of flower initiation*. Under the title Roles of photosynthesis and assimilate partitioning in flower initiation the topic is introduced by R. M. Sachs's most comprehensive and well realized review revealing many facets of the complex interrelationships leading to flowering. Bodson, M. and Remacle, B. present research data on the Distribution of assimilates from various source-leaves during the floral transition of *Sinapis alba* L., while Schwabe, W. W. and Papafotiou, M. focus on the Inhibition of flowering-effects in the leaf and on translocation of the stimulus.

Section VII on *flower development* is introduced by A. H. Halevy's review on Assimilate allocation and flower development postulating the regulatory role of specific carbohydrate components in flower development. The subsequent two papers in this section (The regulation of assimilate partition and inflorescence development in the tomato — by Morris, D. A. and Newell, A. J.; Flower development in the bulbous Iris — by Elphinstone and Rees, A. R.) could very well have been included in the Section VI.

From the present standpoint, in Section VIII. Evans, L. T. makes an attempt to envision *the future*. The paper entitled Towards a better understanding and use of the physiology of flowering can thus be considered as a synopsis of the volume. Some interesting data from this paper: since 1971, 26 000 papers concerned with flowering have been published, about 8000 of which are on day-length and 800 on vernalization. Some promising subtitles of this chapter: Lessons from natural variation, Manipulation by selection and breeding, Environmental, chemical manipulation, Management practices, Time measurement in leaves, Transmission from leaf to shoot apex, Is the medium the message, Morphogens or initiators of transcription clearly reveal the complexity of the topic. It is also relevant that "some of our current mythologies" can only be overcome by asking new kinds of questions about the flowering process, and by applying new experimental techniques including the necessity to gain a molecular foothold on the flowering process.

All in all, the Manipulation of flowering is a precious source of information for all those interested in both theoretical and practical aspects of this field. By providing a comprehensive survey of a wide range of subjects pertaining to the manipulation of this vital physiological process of plants, I warmly recommend this volume as a valuable reference to agronomists, horticulturists, genetists, plant physiologists and plant breeders.

Á. MÁTHÉ

PRINTED IN HUNGARY
Akadémiai Kiadó és Nyomda Vállalat, Budapest

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Index: 26.001

Acta Agronomica Hungarica

VOLUME 37, NUMBERS 3–4, 1988

Akadémiai Kiadó, Budapest

ACTA AGRONOMICA HUNG. HU ISSN 0238–0161

ACTA AGRONOMICA

A QUARTERLY OF THE HUNGARIAN ACADEMY OF SCIENCES

Acta Agronomica publishes papers in English on agronomical subjects, mostly on basic research.

Acta Agronomica is published in yearly volumes of four issues by

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Acta Agronomica Hungarica 37 (3—4), pp. 191—195 (1988)

Plant physiology

IMPROVEMENT IN THE MAGNESIUM SUPPLY OF APPLE ORCHARDS USING DOLOMITE

J. Papp

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(Received 9 April, 1987; accepted 28 April 1987)

In a fruit-yielding apple orchard established on sandy soil with a low pH and poor magnesium supply, studies were made on the effect of fertilization with 2 t/ha or 4 t/ha dolomite or 5 t/ha powdered limestone on changes in the pH value and magnesium content of the soil and the trend in the macro-element content of the leaves and fruit.

The soil ameliorating effect of dolomite fertilization was substantial only in the upper 0–20 cm soil layer. Dolomite treatments significantly raised the amount of readily available magnesium in the soil in all three layers examined (0–20 cm, 20–40 cm, 40–60 cm). The increase of the magnesium content in the soil was considerable even in the year of application.

The seven-year experiment proved that dolomite can be successfully used to improve the basic magnesium supply of the soil in orchards when ground to a diameter of 0.2 mm or less. The decrease in the calcium content of the apple leaves indicates, however, that care must be taken to establish the quantity of dolomite to be distributed. Otherwise, there may be an excessive increase of the available magnesium content in the soil.

Keywords: apples, *Malus domestica*, fertilization, Mg-supply, available magnesium

Introduction

In the course of intensive fruit production the total magnesium, and more specifically the available magnesium content, in the soil may decrease to such an extent that the magnesium supply to the fruit trees will be deficient. There is less danger of this in soils rich in colloids and organic matter.

In Hungary a relatively large area of apple orchards is situated on acidic sandy soil with poor buffering capacity. Magnesium deficiency is often observed in these orchards since the magnesium extracted by the apple trees, or washed out of the soil by precipitation, cannot be replaced from the mineral particles in the soil.

The reduction in the magnesium supply of the apple orchards is not only due to an impoverishment in the magnesium content of the soil. Over the last two decades unfavourable changes in the magnesium supply of orchards can be chiefly associated with high doses of potassium fertilizer. In apple orchards with acidic soil, poor in exchangeable magnesium content, "induced" magnesium deficiency brought about by excessive potassium fertilization may occur suddenly from one year to the next.

Although magnesium deficiencies in apple orchards can be easily and efficiently cured by the use of readily soluble fertilizers or foliar spraying, the application of ground minerals which release their magnesium contents slowly may be preferable for a number of reasons. One such mineral is dolomite, available in large quantities everywhere. Because of its composition ($CaMgCO_3$) it increases not only the magnesium, but also the calcium content of the soil, thus exerting a considerable ameliorative effect.

References to and experimental data on the use of dolomite in improving the magnesium supply of orchards are to be found in the publications of Boynton and Oberly (1966), Childers (1976), Drahorad (1978), Papp et al. (1983), Sadowski et al. (1976) and Wriear (1978).

In the course of the experiment, answers were sought to the following questions:

— Were the chosen ground dolomite products suitable for increasing the pH value and available magnesium content of the apple orchard ?
— To what extent did the magnesium dissolve out of the amount of dolomite applied and did it have a permanent effect ?
— Did the use of dolomite cause an undesirably high increase in the magnesium content of the soil or of the leaves or fruit of the apple trees ?

Material and methods

The dolomite fertilization experiment was arranged in the spring 1979 on the Debrecen State Farm, in Northeastern Hungary. The apple orchard was established in 1963 with Jonathan and Starking varieties planted in rows at a distance of 7.0×4.3 m. The stock was M 4. The orchard has loose sandy soil with a mean pH value (KCl) of the 0–60 cm soil profile of 4.3 and an organic matter content of 0.3%. The orchard was not irrigated and the mean annual rate of precipitation was 562 mm.

Ground dolomite with a diameter of 0.2 mm was used in the experiment. The major chemical components were as follows:

MgO	21%	Fe_2O_3	0.025%
CaO	29%	Na_2O	0.37%
Al_2O_3	0.25%	K_2O	0.13%
SiO_2	0.32%		

Four treatments were applied in the experiment:

(1) Unfertilized
(2) 2 t/ha dolomite
(3) 4 t/ha dolomite
(4) 5 t/ha powdered limestone.

The treatments were arranged in a random block design with four replications. The area of each plot was 0.3 ha.

After the experiment began, the effect of the treatments was checked annually for each plot. Studies were made on changes in the soil of the orchard, also the leaves and the fruit of the apple trees.

During the period from 1979 to 1985 the treatments were repeated in the autumn of 1981 and 1983. The ground dolomite was distributed on the surface of the soil and ploughed to a depth of 15–20 cm.

Results

The present paper demonstrates the effect of the treatments on certain soil characteristics and on the macroelement contents of the leaves and fruit of the apple trees, averaged over the seven years of the experiment. The experimental data provide both a direct and indirect indication of the changes in the magnesium supply of the apple orcharad due to the treatments.

The effect of fertilization with dolomite and powdered limestone on the pH of the soil and on the available phosphorus and magnesium contents are summarized in Table 1 as a 7-year average.

Table 1

Effect of fertilization with dolomite and powdered limestone on the pH value and available phosphorus and magnesium contents of the soil, averaged over seven years, Debrecen State Farm, 1979–1985

Treatment	pH (in KCl)	P_2O_5	Mg
		ppm	
	0—20 cm soil layer		
(1) Untreated	4.3	168	34
(2) 2 t/ha dolomite	5.4	216	93
(3) 4 t/ha dolomite	5.6	174	90
(4) 5 t/ha powdered limestone	5.8	18.3	9.5
$LSD_{5\%}$	0.2	18.3	9.5
	20—40 cm soil layer		
(1) Untreated	4.2	107	34
(2) 2 t/ha dolomite	4.3	119	61
(3) 4 t/ha dolomite	4.3	96	54
(4) 5 t/ha powdered limestone	4.6	142	40
$LSD_{5\%}$	0.2	17.8	8.2
	40—60 cm soil layer		
(1) Untreated	4.2	70	32
(2) 2 t/ha dolomite	4.3	74	62
(3) 4 t/ha dolomite	4.2	60	54
(4) 5 t/ha powdered limestone	4.3	65	40
$LSD_{5\%}$	n.s.	n.s.	8.7

As the results of dolomite treatment the pH value only rose significantly compared to the control in the top 0—20 cm surface soil layer. Treatment with 5 t/ha powdered limestone significantly increased the pH value of the orchard soil in both the 0—20 cm and the 20—40 cm layers, compared to the other treatments.

As expected, the ground dolomite significantly increaed the available magnesium content in all three soil layers (0—20 cm, 20—40, 40—60 cm). The increase was greatest in the 0—20 cm layer, into which the dolomite was ploughed. Compared to the unfertilized and powdered limestone treatments, the dolomite treatments significantly increased the magnesium content in all the soil layers, resulting in magnesium contents favourable for sandy soils.

Table 2

Effect of fertilization with dolomite and powdered limestone on the macroelemts in the leaves of "Johathan" and "Starking" apple trees (% dry matter) Debrecen State Farm, 1979–1985

Treatment	N		P		K		Ca		Mg	
	J	S	J	S	J	S	J	S	J	S
Unfertilized	2.63	2.58	0.150	0.150	1.30	1.56	1.12	1.03	0.300	0.33
2 t/ha dolomite	2.50	2.57	0.149	0.160	1.28	1.48	1.07	1.00	0.32	0.33
4 t/ha dolomite	2.63	2.54	0.146	0.160	1.33	1.47	1.08	1.00	0.32	0.34
5 t/ha powdered limestone	2.57	2.58	0.149	0.160	1.27	1.53	1.17	1.09	0.31	0.33
$LSD_{5\%}$	0.09	n.s.	n.s.	n.s.	n.s.	n.s.	0.07	0.08	n.s.	n.s.

Note: J = "Jonathan", S = "Starking"

Compared to the control the available phosphorus content by dolomite treatments was increased in the 0—20 cm soil layer and by powdered limestone treatment in the 0—20 cm and 20—40 cm layers.

Table 2 contains data on the macroelement contents of the leaves of "Jonathan" and "Starking" apple trees. The dolomite and powdered limestone treatments showed only very comparatively slight differences in the soil. For the majority of nutrients only insignificant effects could be demonstrated for both varieties. The only effect significant at the $LSD_{5\%}$ level for both varieties was the reduction in the calcium content of the leaves after dolomite fertilization, compared with the powdered limestone treatment. This indicates that great care must be taken when determining the dolomite rate. When

Table 3

Effect of dolomite and powdered limestone on the macroelement contents of "Jonathan" apples (mg/100 g freesh mass) Debrecen State Farm, 1979–1985

Treatment	N	P	K	Ca	Mg
Unfertilized	36.4	7.2	141.8	5.3	6.6
2 t/ha dolomite	43.3	7.2	104.5	5.8	6.1
4 t/ha dolomite	41.9	7.3	122.1	5.1	6.6
5 t/ha powdered limestone	42.6	8.0	118.3	5.6	6.2

higher dolomite rates are applied the increase of the available magnesium content may impair the calcium uptake of the apple trees, due to ion antagonism.

The effect of dolomite and powdered limestone fertilization on the macroelement contents of "Jonathan" apples is summarized in Table 3. Compared to the unfertilized treatment, both dolomite and powdered limestone treatments increased the nitrogen content of the fruit and reduced their potassium content. The treatment with powdered limestone also increased the phosphorus content of the apples. The effect of the fertilization treatments on the calcium and magnesium contents of the fruit is contradictory.

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QUANTITATIVE VARIATIONS OF SOME VOLATILE COMPOUNDS IN VARIOUS ONTOGENETICAL PHASES OF *MATRICARIA CHAMOMILLA* L. (*CHAMOMILLA RECUTITA* (L.) RAUSCHERT) GROWN IN PHYTOTRON

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(Received 28 March 1986; accepted 10 November 1986)

In reproductive and vegetative organs of 3 chemotypes of chemomile grown in phytotron, quantitative variations of some biologically active volatile compounds in certain phases of ontogeny were studied. In the reproductive organs the antiphlogistic components — except bisabololoxide-A — were found to increase in the period of full flowering, while the bisabololoxide-A showed maximum value in the phase of deflorescence. The maxima of en-in-dicycloethers with spasmolytic effect were measured in the bud or in the initial phase of flowering. In the vegetative organs the en-in-dicycloethers were the only biologically active components found in larger quantities, with maxima in the phase of flowering.

Keywords: chamomile, *Matricaria chamomilla* L., *Chamomilla recutita* (L.) Rausch., volatile oils, ontogenesis

Introduction

Authors concerned with quantitative variations in the essential oil composition of chamomile give account first of all of variations in the azulene content of the inflorescence. Kaiser and Hasenmeyer (1956), Schenk and Frömming (1958), Schantz and Salonen (1966), Karawya et al. (1968), Kiszeleva et al. (1969) obtained maximum azulene content in full flowering. Stieber et al. (1979) observed an increase in the number of glandular hairs containing proazulene, likewise in the period of full flowering.

The improvement of phytoanalytical methods has made it possible to follow the quantitative variations of almost all major essential oil components (Fig. 1). Franz (1980) used gaschromatography to follow the variations of bisabolol derivatives, azulene, pharnesene, and of en-in-dicycloethers in the inflorescence.

He found that the (—)-α-bisabolol content reached its maximum in the bud, and from that stage on, through full flowering up to deflorescence showed a steady decrease. This process was the opposite of the variations of bisabolol-oxides, the quantity of which continuously increased from the bud stage,

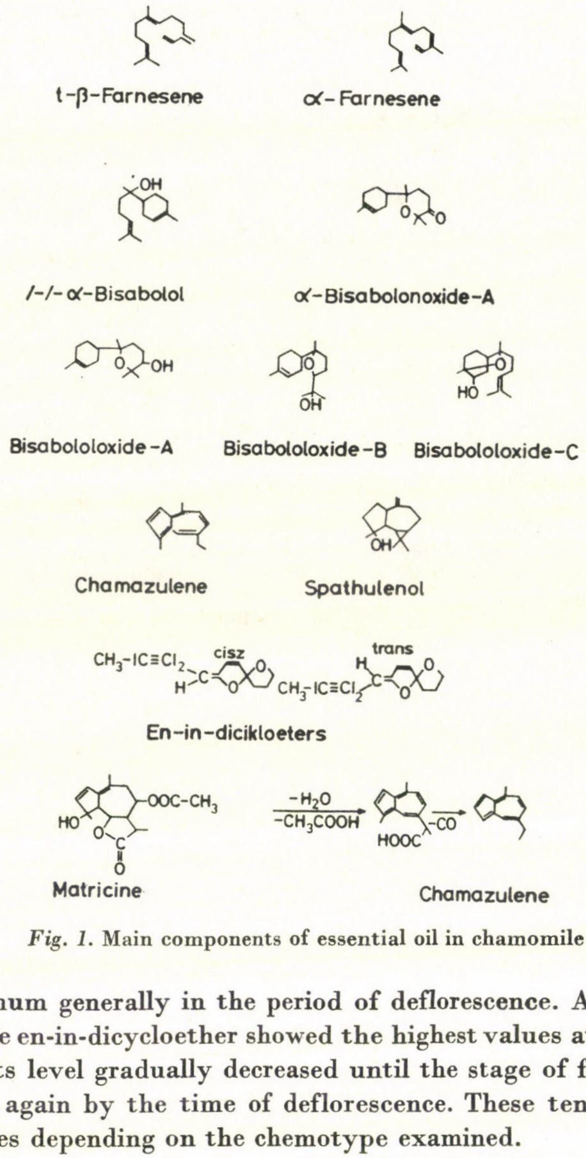

Fig. 1. Main components of essential oil in chamomile

to reach maximum generally in the period of deflorescence. According to his observations the en-in-dicycloether showed the highest values at the bud stage, from then on its level gradually decreased until the stage of full flowering to become higher again by the time of deflorescence. These tendencies showed slight differences depending on the chemotype examined.

From his experiments Franz concluded that the senescence of the inflorescence involved a simultaneous increase in the quantity of oxygen-containing volatile compounds.

In our experiments the variations of (—)-α- bisabolol-, bisabololoxide-, t-β-pharnesene and en-in-dicycloether contents in different development phases of the inflorescence of various chamomile chemotype raised in phytotron were observed and compared with the results obtained by Franz in field experiments.

Table 1

Programme for phytotron experiment

Days No.	Day-time		Temperature, °C		Relative humidity		Illumination lux max.
	Beginning	End	Day	Night	Day	Night	
28	3^{15}	16^{30}	16	15	65	75	20,000
14	2^{45}	16^{45}	17	15	65	75	20,000
14	2^{15}	17^{15}	18	15	65	75	20,000
7	2^{00}	17^{30}	19	15	65	76	16,000
7	2^{00}	17^{30}	20	15	65	76	16,000
7	2^{15}	17^{30}	21	16	65	76	16,000
7	2^{00}	17^{30}	22	17	65	76	16,000
7	1^{45}	17^{30}	23	17	65	76	16,000
2	2^{00}	17^{30}	24	18	65	76	16,000

Beginning of the experiment: 23 March 1977
End of the experiment: 18 July 1977
Type of fluorescent tube: Gro-Lux (WS)

The vegetative organs were also examined for quantitative variations in t-β-pharnesene, spathulenol and en-in-dicycloethers — 3 main components occurring in the inflorescence too — during some characteristic ontogenetic phases of the plant.

Material and methods

The experiments were carried out with the following chamomile chemotypes:

(1) Bisabolol type (collected in Hortobágy, (B_H).*) On a 3-year average the plants contained 110.50 mg % (—)-α-bisabolol and 27 mg % azulene.

(2) Proazulene type (from Soroksár, 40/S_{40}). It is a state registered Hungarian variety. Its azulene content on a 3-year average was 89.90 mg % and its bisabolol content 25.62 mg %.

(3) Proazulene type (from Dar ánypuszta/K_D) On a 3-year average its azulene content was 48 mg %, and its bisabolol content 21.4 mg %.

The programme applied, while the plants were raised in phytotron is given in Table 1.

The times of collecting are shown in Table 2; and the percentage values in this table show how many of the plants examined were then in the respective development phases (leaf-rosette, bud initial flowering, full flowering, deflorescence, fruit ripening). Some 20 plants from each period were chosen for examination. The plants were propagated by sowing. The selected plant material was reduced to organs and dried at room temperature overtwo weeks.

The essential oil content was extracted with a modified form of the volatile oil distilling apparatus of the VI. Hungarian Pharmacopoeia, furnished with a double cooling system to eliminate losses of volatile oil. Distillation from 2–10 g drugs depending on the part of plant, with 500 ml water added to them took 2.5 hours. After cooling the essential oil was released from the apparatus with n-pentane, separated from the water in a shaker, then the organic solvent was removed and the residue of essential oil weighed.

The analysis of the essential oil composition was carried out by gaschromatography elaborated at the Institute of Medicinal Plants and Drugs of the Semmelweis Medical University. The quantitative evaluation of the components was made by an internal standard method (Verzár and Petri, Lemberkovics, 1976).

* Region in Eastern Hungary.

Table 2

Harvesting times of chamomile types grown in phytotron and respective stages of ontogenetic development (the percentage values show how many of the plants were in the development phase indicated at the time of harvesting)

Plant material	Time of sowing 26 Februar 26th	49th	90th	100th	137th
	day after sowing				
B_H	Vegetative phase, average number of leaf-rosette: 5 (100%)	Bud stage (69.80%)	Flowering phase (94.56%)	Flowering phase (92.50%)	Deflores-cence (69.41%)
S_{40}	Vegetative phase, average number of leaf rosette: 6 (100%)	Bud stage (64.70%)	Bud stage (80%)	Bud stage (90.48%)	Deflores-cence phase (50%)
K_D	Vegetative phase, average number of leaf-rosette: 5 (100%)	Bud stage (59.80%)	Flowering phase (62.27%)	Flowering phase (91.30)	Deflores-cence phase (93.10%)

Plant material	Time of sowing 26 Februar 26th	173rd	214th	229th	268th
	day after sowing				
B_H	Vegetative phase, average number or leaf rosette 5 (100%)	Deflores-cence phase (100%)	Deflores-cence phase (80%)	Fruit ripen-ing phase (100%)	Fruit ripen-ing phase (100%)
S_{40}	Vegetative phase, average number of leaf-rosette 6 (100%)	Deflores-cence phase (98.18%)	Deflores-cence phase (69.00%)	Fruit ripen-ing phase (80.00%)	Fruit ripen-ing phase (100%)
K_D	Vegetative phase average number of leaf-rosette 5 (100%)	Deflores-cence phase (20%)	Deflores-cence phase (80.00%)	Fruit ripen-ing phase (90.00%)	Fruit ripen-ing phase (100%)

Results

From the main components of the floral essential oils in the case of S_{40} and K_D the maximum of chamazulene was measured at the beginning of flowering while for B_H only in the phase of full flowering. The highest value of (—)-α-bisabolol was determined in full flowering for all the three chemotypes. Of the bisabololoxides, bisabololoxide B showed the maximum in the phase of full flowering while bisabololoxide A in the period of deflorescence (Fig. 2).

The quantity of t-β-pharnesene of the two chamazulene chemotypes was largest in the bud stage, while of the B_H it gave the highest value in the phase of deflorescence. After that it decreased, only to rise again by the time of fruit ripening.

Increases in the quantity of en-in-dicycloethers were observed partly in the period of budding (S_{40}, B_H) and partly in the initial phase of flowering (K_D). From this peak to the time of fruit ripening, their quantities gradually decreased (Fig. 3).

To those variations as followed by us in the vegetative organs, no reference in the literature has been found so far. So the quantitative variations of t-β-pharmasene, spathulenol and en-in-dicycloethers in the root and in the stem and leaf during the ontogenetic phases in question are first mentioned by us.

In the root of both S_{40} and K_D t-β-pharasene reached its maximum in the period of flowering. From the vegetative leaf-rosette stage to budding its quantity decreased, then up to the phase of flowering it showed a gradual increase followed by a sharp reduction by the time of deflorescence. The process was similar in the case of B_H except that the maximum here was observed in the vegetative phase.

The quantitative variations of en-in-dicycloethers matched with those of t-β-pharnasene. The highest values were measured in the phase of flowering. However, one single opposite variation was noticed. Namely, the quantity of en-in-dicycloethers showed a slow increase from deflorescing to fuit ripening, which was not observed for t-β-pharnesene.

The least variations during the ontogenetic development was noticed in the case of spathulenol. Its quantity from the vegetative stage to fruit ripening, or in K_D to deflorescing, steadily decreased. In the latter chemotype, from deflorescing to fruit ripening a slow increase in its quantity could be observed (Fig. 4).

The variations followed in the stem and leaf were similar to those taking place in the root. The highest value of t-β-pharnesene was obtained in the vegetative phase (except for K_D). In the case of K_D the maximum was measured in the period of flowering. Altogether the t-β-pharnesene content showed the following trend: from the vegetative stage to budding it gradually decreased, then by the time of flowering it rose; from then on it decreased again to a nearly steady level maintained until the time of fruit ripening.

The variation of en-in-dicycloethers showed a similar trend. Maxima were measured in the vegetative stage for B_H and S_{40}, and in the phase of flowering for K_D.

The spathulenol content steadily decreased from the vegetative phase to fruit ripening, before flowering at a slower, and after flowering, at a faster rate (Fig. 5).

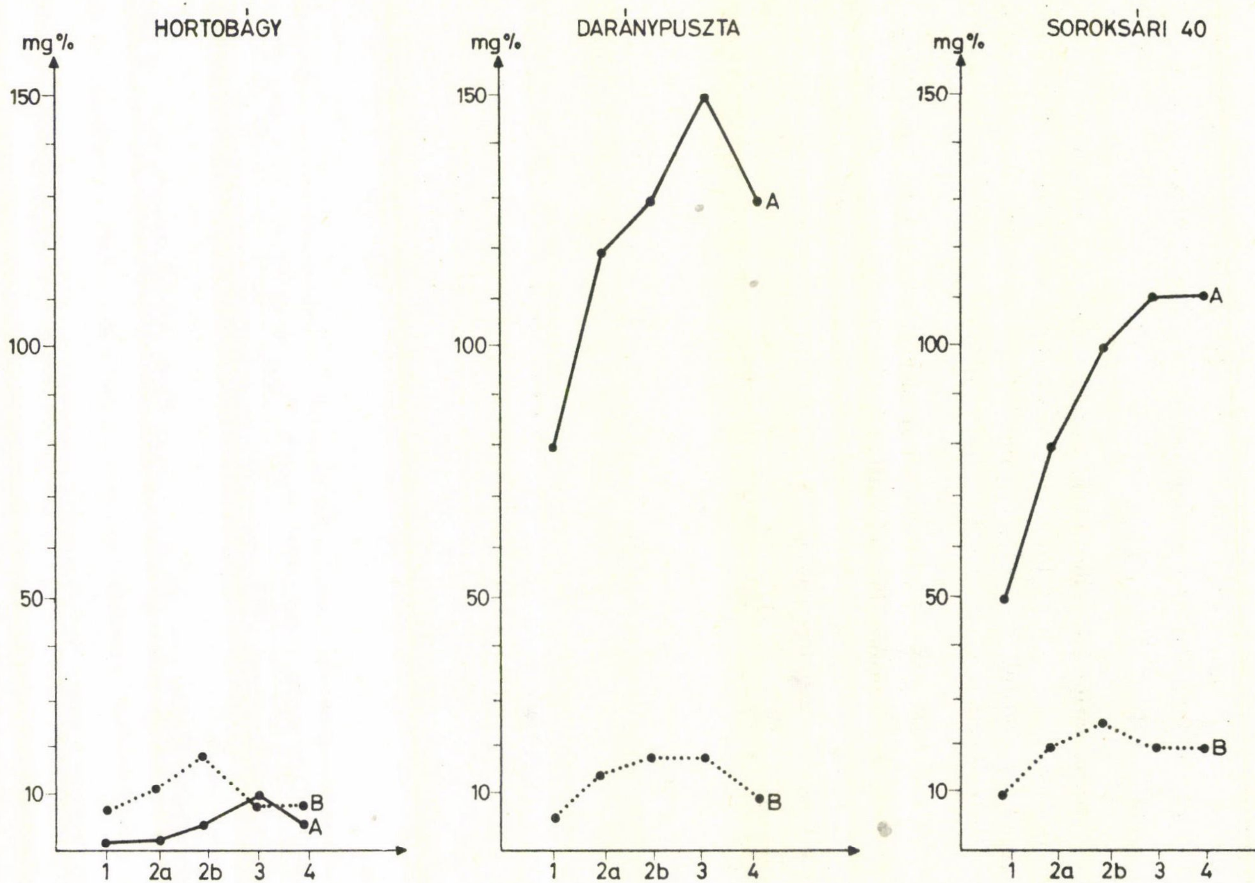

Fig. 2. Quantitative variation in essential oil components of inflorescence in some phase of ontogenetic development (mg%) 1 = budding; 2a = beginning of flowering; 2b = full flowering; 3 = deflorescence; 4 = fruit ripening. A = bisabololoxide-A. B = bisabololoxide-B

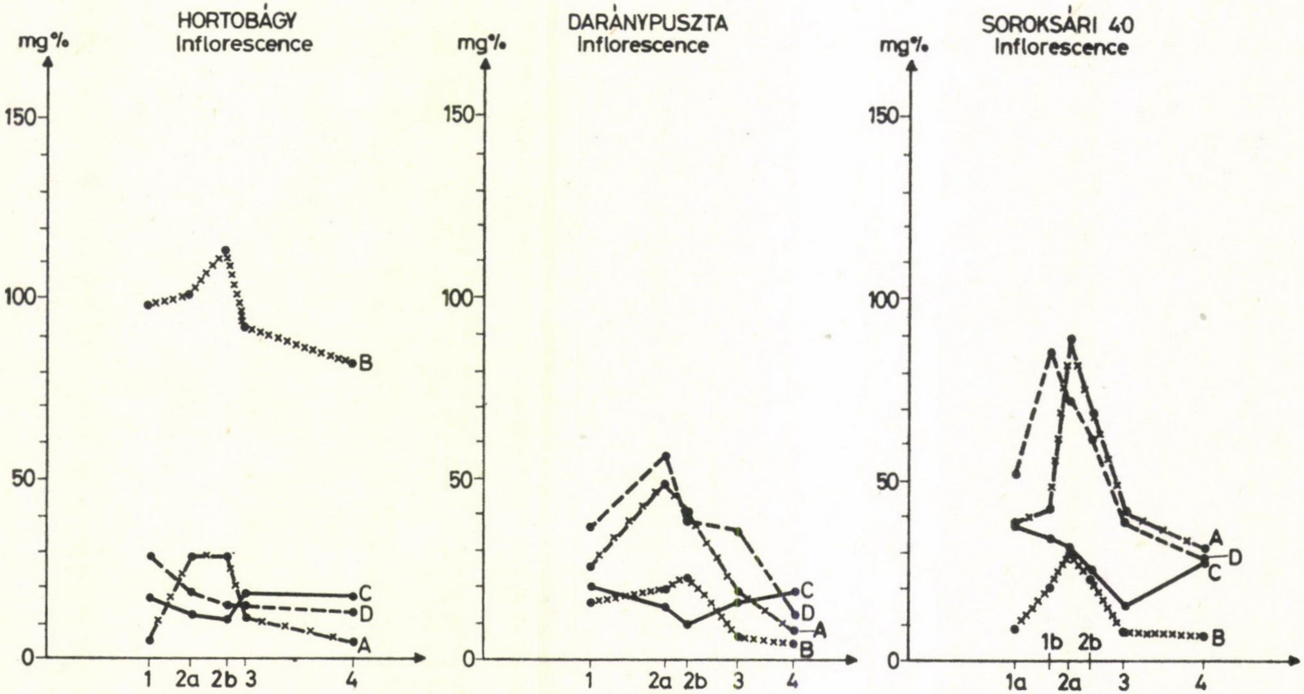

Fig. 3. Quantitative variation in essential oil components of inflorescence in some phase of ontogenetic development (mg%) 1a = budding, the ligulate flowers have not developed yet; 1b = budding, the ligulate flowers have appeared; 2a = beginning of flowering, the ligulate flowers have opened, the tubular flowers are closed; 2b = full flowering, the ligulate flowers are outstretched, the tubular flowers open; 3 = deflorescence; 4 = fruit ripening. A = chamazulene; B = (—)-α-bisabolol; C = = t-β-farnezene; D = en-in-dicycloethers

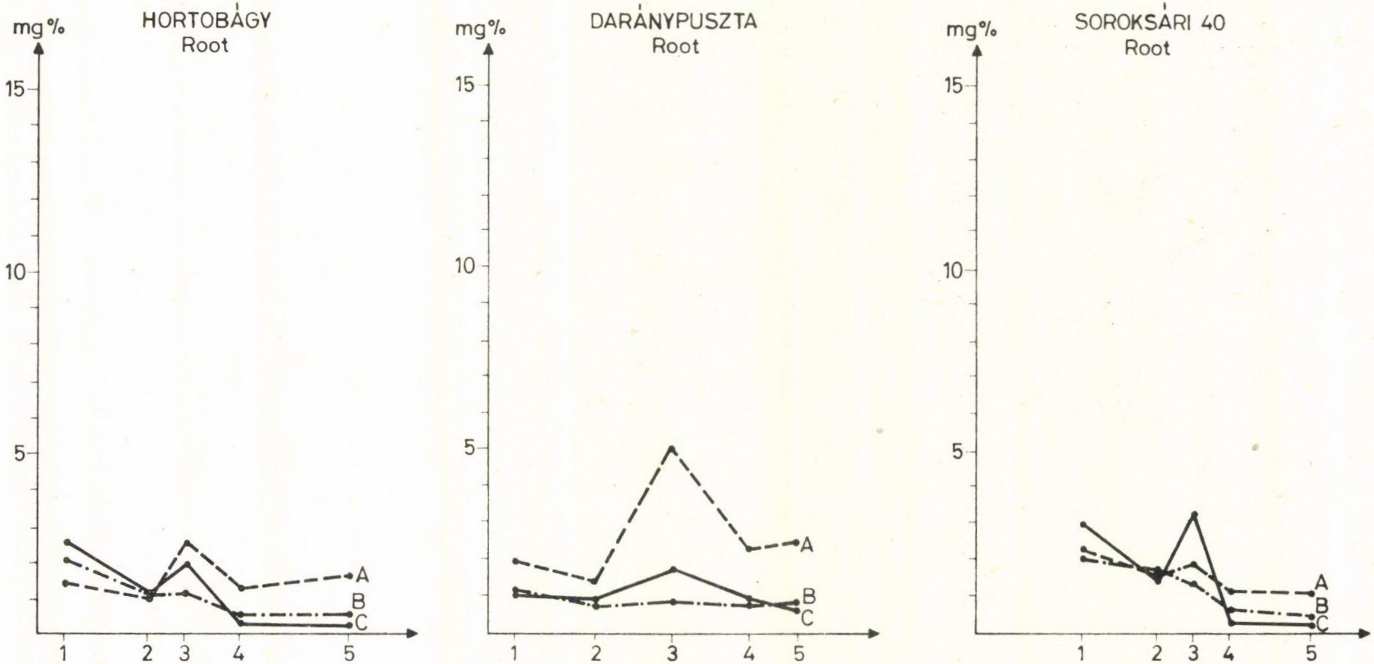

Fig. 4. Quantitative variation in main components of essential oil in the root in some phases of ontogenetic development (mg%) 1 = vegetative (leaf-rosette) stage; 2 = budding; 3 = full flowering; 4 = deflorescence; 5 = fruit ripening. A = en-in-dicycloethers B = spathulenol C = t-β-farnesene

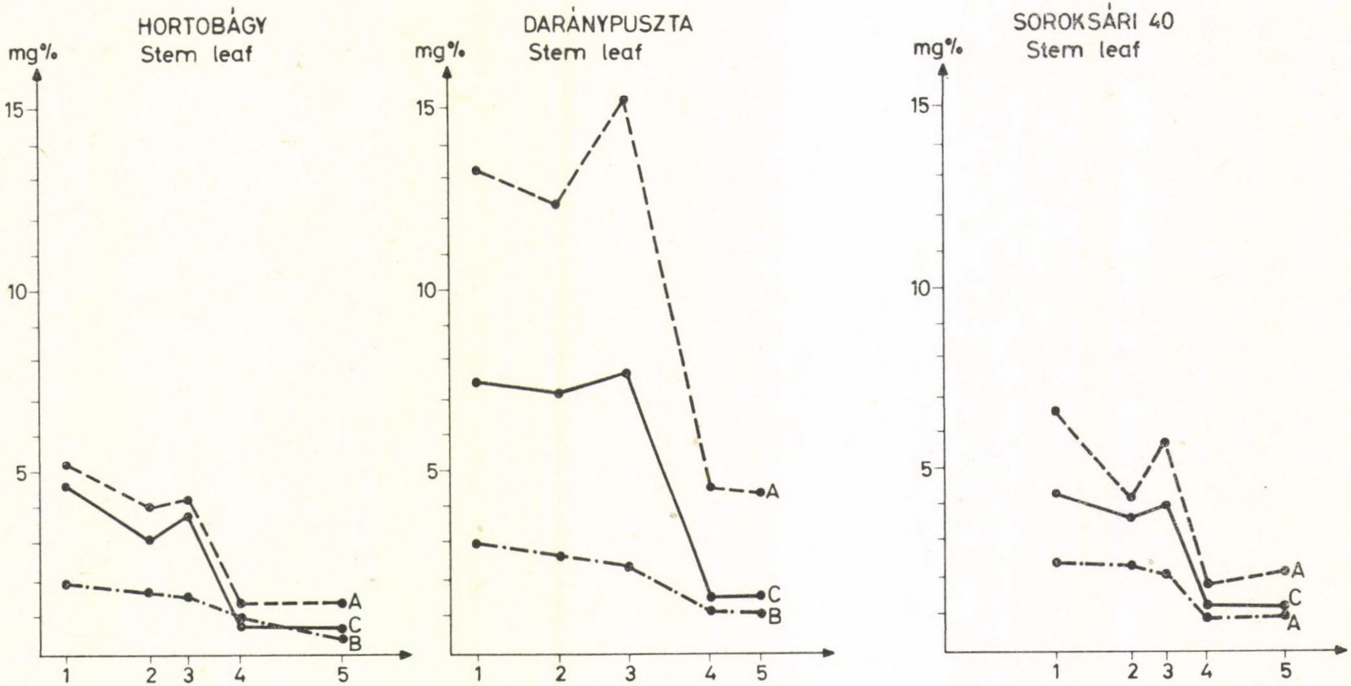

Fig. 5. Quantitative variation in main components of essential oil in the stem and leaf in some phase of ontogenetic development (mg%). 1 = vegetative (leaf-rosette) stage; 2 = budding; 3 = full flowering; 4 = deflorescence; 5 = fruit ripening. A = en-in-dicycloethers B = spathulenol C = t-β-farnesene

Table 3

Comparative examination of the morphological quality between

	Height (cm)		Ramification		Inflorescence-bud	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Darány puszta (Phytotron)	48.40	5.936	6.20	2.821	50.70	7.110
Daránypuszta (Control)	53.60	7.432	6.70	1.900	73.60	12.190
Hortobágy (Phytotron)	29.00	2.828	4.00	1.182	39.00	8.143
Hortobágy (Control)	22.80	4.935	13.00	3.660	53.20	14.030
"Soroksári 40" (Phytotron)	57.40	3.638	6.80	1.939	23.80	6.415
"Soroksári 40" (Control)	65.00	6.403	4.90	1.700	48.90	16.270

During the ontogenetic development of each of the three chemotypes there was a linear correlation between the quantities of t-β-pharnesene and spathulenol:

$$B_H \quad r = 0.937 \qquad n = 5$$
$$S_{40} \quad r = 0.986 \qquad n = 5$$
$$K_D \quad r = 0.962 \qquad n = 5$$

Conclusions

A comparison between our phytotron experiments and the field experiments of Franz (1980) has led to the following conclusions:

The maximum of the azulene content in either case was measured in an earlier or later phase of flowering depending on the chemotype. In the azulene chemotypes, peak values were already obtained in the initial phase of flowering.

In our experiments, as opposed to the results of Franz (1980), (—)-α-bisabolol accumulation was observed in the stage of full flowering. Furthermore, differences were found between the two bisabololoxides as regards the period of accumulation; bisabololoxide A and B reached maximum in different development phases.

The highest values of en-in-dicycloethers were found in bud stage in both experiment series, but the increase described by Franz as characteristic of the phase of deflorescence was not observed in our experiments.

Variations in the vegetative organs concerned 3 characteristic components occurring in the inflorescence too: the t-β-pharnesene, the spathulenol and the en-in-dicycloethers. According to our observations the quantitative variations of t-β-pharnesene and en-in-dicycloethers were the opposite of those found in the inflorescence.

in-phytotron, respectively out door growing chamomile types

Bud-number		Dry matter (g) of 100 inflorescence		Dry matter (g) of stem and leaf		Dry matter (g) of the root	
		per plant					
$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
24.40	8.114	2.56	0.470	4.77	0.859	3.11	0.958
5.00	3.430	3.45	0.262	6.56	2.570	1.10	0.376
19.50	6.888	1.78	0.077	2.86	0.526	1.78	1.090
—	—	2.00	0.043	3.03	2.890	1.36	0.761
17.10	4.948	3.03	0.384	6.30	1.320	3.26	0.799
7.20	0.820	3.94	0.075	5.95	2.748	0.70	0.232

Acknowledgements

On completing our work we are to express our thanks to S. Rajki, D. academician and Mrs S. Rajki, D. candidate in biological sciences, for their placing the phytotron of the Martonvásár Agricultural Research Institute of the Hungarian Academy of Sciences at our disposal and setting up the phytotron programme.

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Acta Agronomica Hungarica 37 (3—4), pp. 209—213 (1988)

NONDESTRUCTIVE PROMPT NEUTRON ACTIVATION TECHNIQUE FOR DETERMINING BORON UPTAKE AND DISTRIBUTION IN PLANTS

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(Received 3 April 1987; accepted 13 July 1987)

A sensitive instrumental prompt activation method — based on the $^{10}B/n, \alpha/^{7}Li$ nuclear reaction — was applied for boron determination, using a pulsing reactor as a neutron source. The technique was used for determining boron uptake and distribution by maize and bean.

Keywords: activation analysis, bean, boron, maize, neutron activation, prompt nuclear technique, radiography

Introduction

For almost 80 years it has been known that boron is one of the essential trace elements for plants. Under Central European conditions, boron is the most important of the microelements for the growth development, yield and quality of cultivated plants (Mengel, 1972). Below the minimum values of boron concentration (e.g. for barley 2 ppm, for cucumber 15 ppm, based on dry weight of the leaves) symptoms of boron deficiency — leaf chlorosis and necrosis — appear (Bowen, 1977).

Boron deficiency can be observed in many cases, e.g. soils in high rainfall areas are often dificient in boron. But fertilization with boron is rather difficult because excessive boron is toxic to plants, and the interval between deficiency and excess is narrow.

The biological role and the transport of boron in plants have not been completely clarified (Bogáncs et al., 1979; Varró et al., 1982; Krakkai and Kőrösi, 1983; Artez et al., 1984). This lack of knowledge is probably linked with the fact that boron is rather difficult to analyse, and the determination of boron in the ppm concentration range requires very sensitive analytical techniques.

In the following, a nondestructive prompt neutron activation technique (INAA) will be described, which is also suitable for analysing plant samples with very low boron concentrations.

Material and methods

The prompt neutron activation technique was utilized to determine the boron concentration and distribution in leaves of bean *(Phaseolus vulgaris)* and maize *(Zea mays)* plants, grown in nutrient solutions. The boron was added to the Knop solution in the form of H_3BO_3. The treatments were carried out with six-week-old plants (3 leaves age).

After the treatments the leaves were cut from the stem and dried at room temperature. The samples were prepared at the University of Agricultural Sciences, Gödöllő, Hungary.

For the boron measurements, 3 different methods, based on the $^{10}B/n, \alpha/^7Li$ nuclear reaction, were applied. Since these methods were described in detail in our previous work (Bogáncs et al. 1979; Szabó et al. 1980; Szabó 1981), here only some essential points are given.

Because of the very high cross section ($\sim$3800 barn) of this (n, α) reaction the methods, based on the $^{10}B/n, \alpha/^7Li$ reaction, are sensitive. The measurements, using a time of flight technique on the IBR-30 pulsing reactor, were carried out in the Joint Institute for Nuclear Research, Dubna, USSR.

The first method was the detection of the prompt a-particles, produced in the $^{10}B/n, \alpha/^7Li$ nuclear reaction, with a surface barrier silicon detector in a vacuum chamber. The thermal neutron flux amounted to $\sim 10^6$ n $\cdot$ cm^{-2} $\cdot$ s^{-1} at the measuring place.

The second method was neutron-induced α-radiography, using a solid state track detector (type: LR-115). This SSTD consists of a thin sensitive cellulose nitrate layer on an inert polyester sheet. These measurements were carried out in a paraffin box — not in the direct neutron beam — where the average thermal neutron flux reached 10^7n $\cdot$ cm^{-2} $\cdot$ s^{-1}.

The third method was the detection of prompt γ-rays from the $^{10}B/n, \alpha/^7Li$ reaction, with a high resolution Ge(Li) detector.

Results and discussion

Table 1 shows the boron concentration in maize leaves as a function of the boron concentration in the nutrient solution, duration of the treatment and place of the leaves on the stem. The boron content of the leaves increased with the concentration in the nutrient solution and duration. It can be seen that the plants absorb the boron easily, and the uptake can be far greater (also phytotoxic) than the real physiological need. Results show that the translocation between the leaves is small, or the older leaves absorb less than the younger ones (Table 1).

We also investigated the surface boron distribution of the leaves (Figs 1, 2 and 3). It can be seen that — if the boron concentration of the leaves is

Table 1

Boron concentration in maize leaves in 10^{20} B atom $\cdot$ cm^{-3} unit

Duration of treatment	Leaf position on stem	Boron concentration in the Knop nutrient solution (ppm)			
		100	10	1	control
24	Upper leaf	1.92	0.57	0.28	0.15
	Lower leaf	1.19	0.22	0.10	0.07
72	Upper leaf	8.57	0.79	0.65	0.35
	Lower leaf	2.20	0.46	0.19	0.15

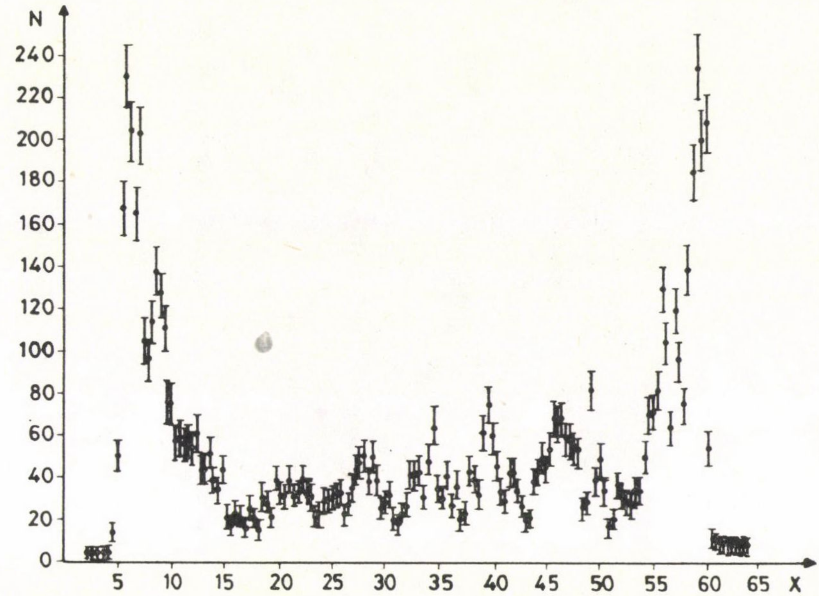

Fig. 1. Half bean leaf (treated 72 h in nutrient solution with 1000 ppm boron) investigated by α-radiography. The arrow shows the direction of the measurement on Fig. 2. White field — high boron content; black field — low boron content

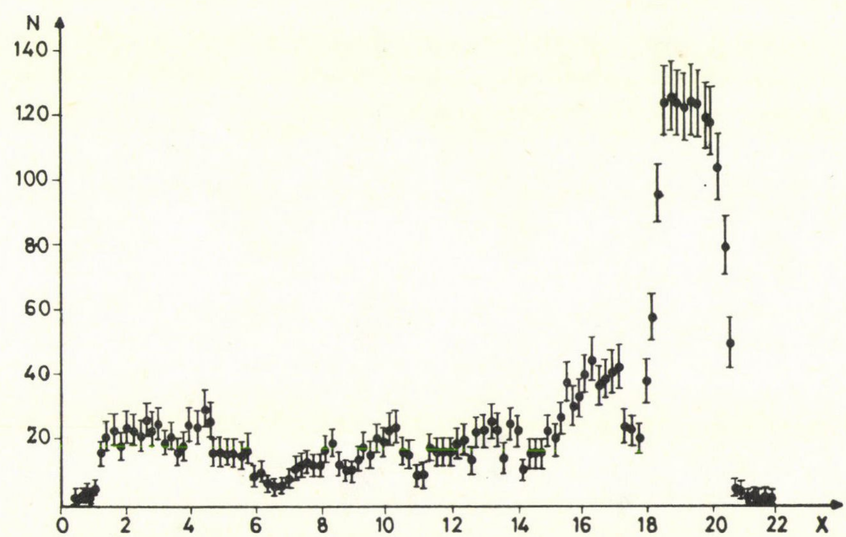

Fig. 2. Surface boron distribution broadwise on the half bean leaf X — distance in mm from the centre to the edge of the leaf N — number of detected d-tracks

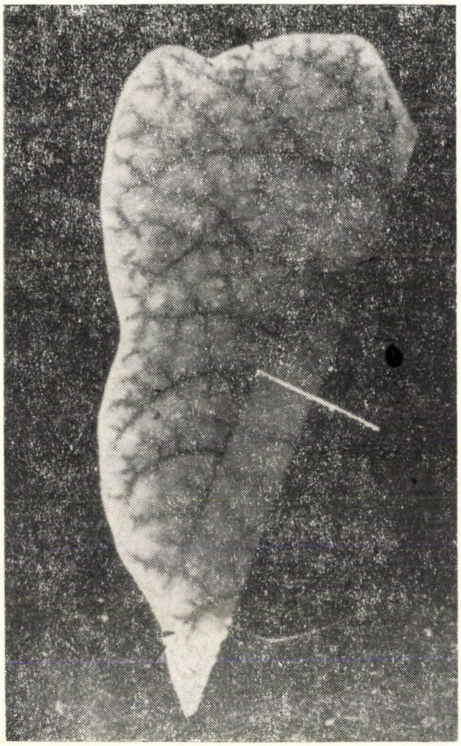

Fig. 3. Surface boron distribution alongside the half bean leaf X — distance in mm to the peak of the leaf N — number of detected d-tracks

much higher than the physiological requirement — the distribution is not homogeneous: at the edges and the peak of the leaves the boron concentration is significantly greater. The accumulation of boron at the edges and the peak of the leaves depends on the transpiration intensity.

The boron concentration on both sides of the leaves was also measured, (Table 2). Although the mean surface concentrations on every measured leaf

Table 2

Surface boron concentration on the right (sunny) and back (shady) sides of bean leaves 10^{20} B atom · cm^{-3} unit

No. of sample	Side	Boron concentration
1	Right	0.464 + 0.028
	Back	0.538 + 0.116
2	Right	1.056 + 0.132
	Back	1.136 + 0.120
3	Right	0.559 + 0.035
	Back	0.578 + 0.043

were, in general, 5–10 % greater on the back, in consequence of the error limits of the determination these differences are not significant.

It is mentioned, that the boron determination limit of the first method (measuring the α-particles with silicon detector) was 2.10^{-7} g, by α-radiography $\sim$0.2 ppm, and by γ-spectrometry $\sim 10 \mu g$. (Table 2).

Conclusion

As a conclusion it can be established that this instrumental nuclear technique provides the possibility of investigating the uptake, transport, distribution and translocation of boron in plants. Using the prompt neutron activation method, based on the nuclear reaction $^{10}B/n, \alpha/^{7}Li$, boron determination is possible even in the case of small plant samples or very low boron content.

Acknowledgement

The authors wish to thank J. Bogáncs, I. Krakkari and V. M. Nazarov for collaboration and discussions.

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Acta Agronomica Hungarica 37 (3—4), pp. 215—225 (1988)

SEED VIGOUR OF HYBRID MAIZE AS DETERMINED BY COLD TEST AND AFFECTED BY MACRO-ENVIRONMENTAL CONDITIONS IN HUNGARY

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The germination percentage of cold test was determined as an indicator of maize seed vigour. The seeds of two hybrids were produced at various locations of central and southern Hungary, in 1982 and 1983. Weather conditions during these growing seasons influenced the seeds produced, especially in 1983, which had the effect of drought stress (low rainfall and high temperature). The effect of the location and year was highly significant on the seed vigour of hybrid maize. Therefore, seed vigour of each hybrid must be evaluated in several locations over more than two years, for the selection of genotypes tolerant to stress conditions.

Keywords: maize, *Zea mays* L., seed vigour, cold test, macro-environmental conditions

Introduction

Seed vigour is a desirable trait in virtually all cultivated crops. Seedmen, seed technologists and plant breeders have conducted a search for the basis of, and a testing procedure for, increased seedling vigour. A number of laboratory tests such as the cold test have been proposed for its evaluation, and they continue to be used as vigour indices (Burris 1975). The cold test is one of the oldest methods of stressing seeds and is most often employed for evaluations of the seed vigour in corn (McDonald, Jr. 1980). A cold test method has been adopted in many countries where maize is sown in early spring, when temperatures are low, to provide a reliable prediction of field emergence. Therefore it is necessary to carry out a test under suboptimal conditions, and the cold test has been used widely for this purpose by plant breeders (Jugenheimer 1958; Tovmasjan 1965).

Isely (1950) stated that the emergence of maize in cool, wet soils depends not only on inherited characteristics but on many external factors which influence the seed quality. Svien and Isely (1955) and Rice (1960) studied variations in the environmental conditions to which seeds are exposed during the cold test and they found that, in addition to the temperature and length of time it was imposed, and mode of sowing the seeds, soil characteristics such

Table 1

Monthly amount of precipitation and mean of

Location	Year	Precipitation (mm)						
		IV	V	VI	VII	VIII	IX	Total
Mezőfalva	82	32	47	45	212	72	16	424
	83	26	80	29	11	31	28	206
Törökszentmiklós	82	39	75	45	69	39	34	301
	83	41	44	55	29	30	61	260
Hidashát	82	51	27	117	72	39	32	338
	83	31	47	78	34	51	66	307
Hódmezővásár-hely	82	36	10	85	99	40	9	279
	83	32	39	45	27	51	58	252
Bóly	82	35	19	123	90	71	13	351
	83	25	33	94	27	46	69	294
Mean	82	38.6	35.6	83.0	108.4	52.2	20.8	338.6
	83	31.4	48.6	60.2	25.5	41.8	56.6	263.8

as moisture content, origin, conditions of storage and microbial populations were all factors influencing the magnitude and reproducibility of the results. Comparative laboratory and field experiments by Ader (1977) have shown that under certain environmental conditions there are close relations between the results of the cold test and the field emergence. In a series of experiments over three years at two locations, Fiala (1978) showed highly significant positive regressions between the number of vigourous seedlings in the cold test and field emergence, although (Burris 1977) mentioned that the failure to relate seedling vigour to yield has been equated with the failure of a laboratory test to predict the seedling vigour.

Kramer (1959) described drought as a severe deficiency of soil moisture which brings about an internal water deficiency in plants that ultimately results in reduced plant growth. He added that atmospheric factors such as high temperature, low humidity, and wind may intensify the injurious effects of water stress through an increased rate of transpiration. The acute deficiencies in moisture supply resulting from a temporary but severe drought can have disastrous effects. A drought during the seed development period usually interrupts the seed development and results in light, shriveled seeds (Delouche 1980).

Comstock and Moll (1963) classified environments in two categories macro- and micro-environmental variations. Macro-environmental variation is caused by fluctuation in variables which have a large and easily recognized variation (i.e. year, location, fertility, sowing dates, plant density); whereas *temperature for each location and year**

Location	Year	Temperature (°C)						
		IV	V	VI	VII	VIII	IX	Total
Mezőfalva	82	7.8	15.9	18.7	19.8	20.2	13.8	100.7
	83	12.5	17.0	18.4	23.2	20.6	15.9	107.6
Törökszentmiklós	82	8.3	16.9	19.9	21.9	21.0	19.2	106.3
	83	12.9	17.9	19.1	22.7	21.0	16.7	110.3
Hidasháti	82	7.9	16.8	19.5	20.4	20.7	9.4	104.7
	83	12.5	17.5	18.6	22.0	20.2	15.9	106.7
Hódmezővásár-hely	82	8.1	17.9	20.2	20.6	20.6	19.2	106.5
	83	13.2	18.1	19.0	22.9	16.4	110.6	
Bóly	82	8.8	17.5	20.9	21.3	21.1	20.1	109.7
	83	13.6	18.0	19.2	23.1	21.2	16.9	112.0
Mean	82	8.2	16.9	19.8	20.8	20.7	16.3	105.6
	83	12.9	17.7	18.8	22.8	16.4	109.4	

*(re. Central Meteorology Institute, Budapest)

micro-environmental variations arise from plant-to-plant variations within the macro-environments. Moreover, the differences in climate between growing seasons in the production areas of different cultivars may be reflected in variations in seed quality. The environmental conditions under which a seedling is grown influence the morphological and physiological properties of the seed. But other properties are also influenced, such as the health condition of the seed. The environmental conditions, a complex of interacting factors, vary considerably from year to year and locality to locality (Bekendam 1975). The only control a plant breeder has in regard to the year is the length of time a cultivar can be tested; however, locations, can be varied in number, can be divided into regions, and can be selected to measure specific traits. This justifies a greater emphasis on interactions involving cultivars and locations than that for cultivar × year interactions (Horner and Frey 1957; Laing et al. 1966 and Campbell and Lafever 1977). Therefore the primary purpose of this investigation was to study the effect of environmental variables, including locality and crop year on the germination percentage of cold test, as an indication of the seed vigour in hybrid maize.

Material and methods

The maize seeds of two cultivated hybrids were used Pioneer 3901 SC and Pioneer 3732 SC. The seed samples were obtained from five locations Mezőfalva, Törökszentmiklós, Hidasháti, Hódmezővásárhely and Bóly in central and southern Hungary during 1982 and

1983. All agricultural processes were carried out and seed samplings were collected according to the standard procedure used at each location. There may have been slight differences in methods, but it was assumed that the relative differences in the hybrid seeds' response were constant. In general, weather conditions were normal for the growing season of 1982 with respect to all mentioned locations, but were abnormal in 1983, when the rainfall was low and the temperature high (dry season or drought stress), as is shown in Table 1.

After harvest and drying, four seed samples were taken at random from each location to determine the cold test as a seed vigour indicator. This experiment was designed in a randomized complete block, with four replications, where four determinations of cold test per each sample averaged as one replicate value. Thus, four replications were considered for each location. In addition, the locations and years were considered as 10 different environments for each hybrid.

Cold test method

This test provides a reliable prediction for field emergence. Therefore, in the present work, seeds were sown in rolled paper soil, placed in cold conditions (10 °C) and later transferred to a high temperature (25 °C) favourable for germination. It was carried out according to that which is normally used at the Institue for Plant Production and Qualification (Budapest), and has been described in detail by Fiala (1981). The replication value was computed over four replicates of 50 seeds per sample of each treatment and was expressed as a percentage germination.

The data were subjected to a combined analysis, to determine relative magnitudes of pertinent variance components, where it was assumed that the hybrid and location effects were fixed and the year was random. The means were compared using the LLSD test at the 5% level of probability.

Results and discussion

The weather conditions during both cropping yers were substantially different. Precipitation and temperature, however, are the only factors considered here (Fig. 1). During 1982 it was cool with normal precipitation during the seedling stage, and moderate with lower precipitation demands in the first period of the vegetative stage. The precipitation was higher during the flowering and lower during grain maturation. In 1983 it was relatively warmer with lower moisture demands during the seedling stage and flowering. In September 1983 a normal amount of rain fell at the last period of the grain fill stage. This may appear to influence the vigour of seed produced which had already been determined for all locations. These atmospheric factors were also different from location to location, as shown in Fig. 2. The precipitation distribution at the five locations of the study are representative of the normal variation in 1982, but it was below normal in 1983. For example, the Mezőfalva location had abundant seasonal precipitation in 1982 and had an abnormally lower seasonal precipitation in 1983. In relation to the heat requirement, each stage of the growing season varied within a relatively narrow range. Comparably 1983 was considered a dry season, with a higher than ideal temperature which led to drought stress.

The data of cold test response of hybrids appeared similar for both years at all locations. Then the combined analysis of variance above years and

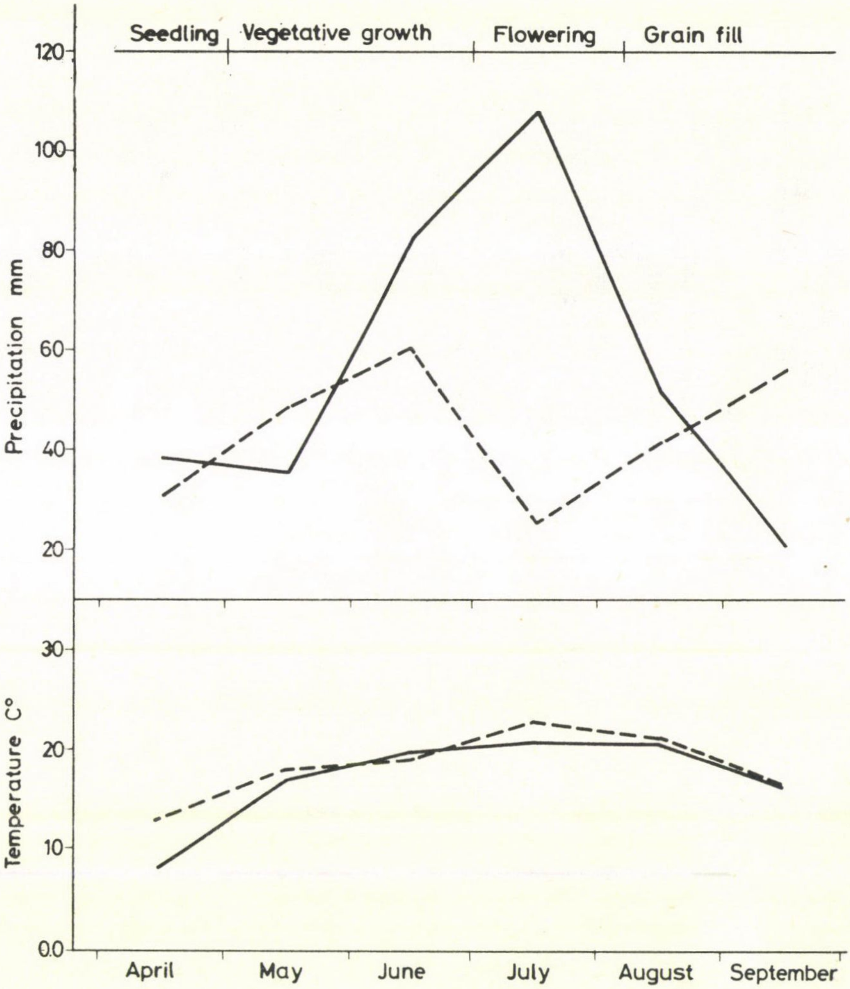

Fig. 1. Monthly mean of daily air temperature (T), and amount of precipitation (P) averaged over locations from sowing to harvest in 1982 (———) and 1983 (– – –)

locations was based on the expected mean square, as shown in Table 2. F-value for location and year were significant and highly significant, respectively. Also, the relative magnitude of the variance component for year and location were much greater than those for hybrid and interaction effects. The interaction of (hybrid × location) indicated that there was no response of the genotypes to the change in the different locations. It would appear that this environment has no affect upon the variation between the two hybrids used. The significance of the location effect indicates that the maize seed vigour responded to the change in the five location conditions. The variation between

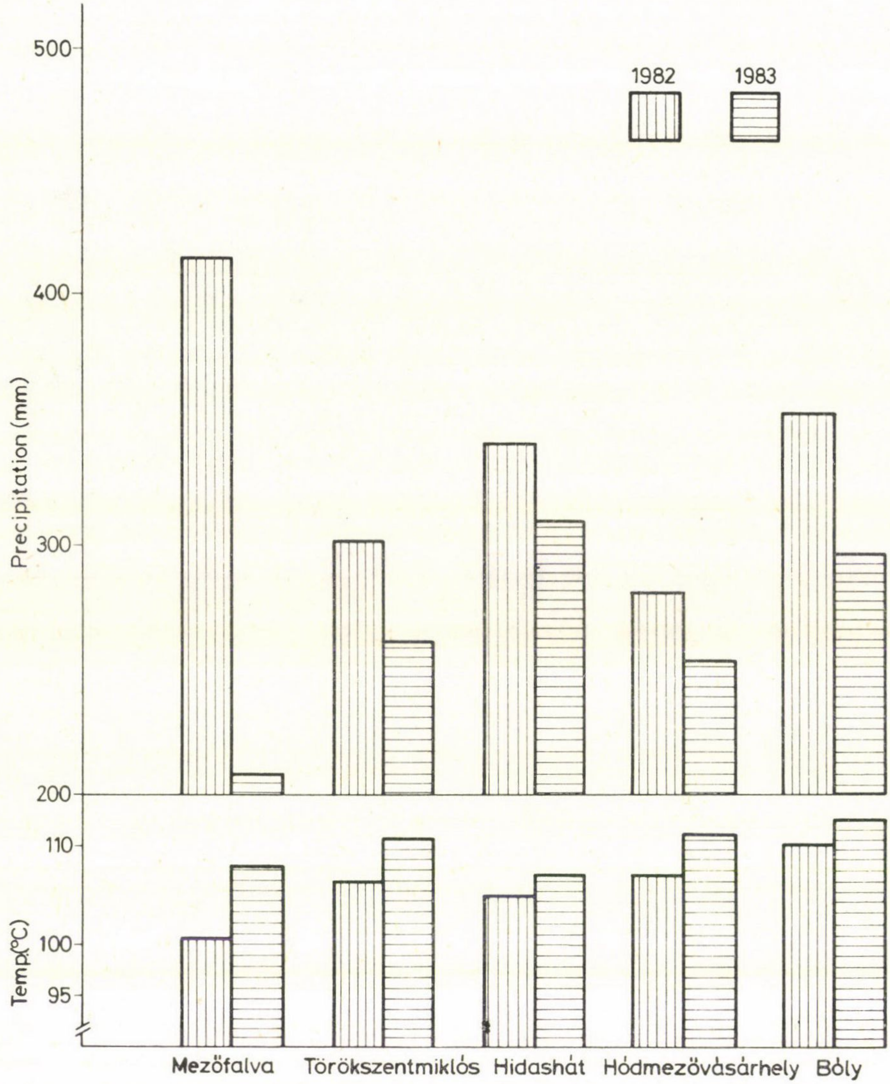

Fig. 2. The total amount of precipitation and monthly mean of temperature for the period from April to Sept., 1982 and 1983 at five locations

both hybrids was significant at (P = 10%). This would indicate that the magnitude of genetic variation was inconsiderable, though it differed in the tested environments. It may be concluded that the maize seed vigour was mainly affected by the location of the seed production and partially by the genetic variation.

Table 2

Combined analyses of pertinent variance components for seed vigour of two maize hybrids in five locations over two crop years

S. O V.	d.f.	M. s.	Expected M. S. for A., B fixed and C random	F-value	
Hybrid (H)	1	25.31	$\sigma e^2 + rlK^2HY + rlyK^2H$	H/HY	93.9^{+}
Location (L)	4	354.70	$\sigma e^2 + rhK^2LY + rhyK^2L$	L/LY	8.4^{*}
Year (Y)	1	221.11	$\sigma e^2 + rhl\sigma Y^2$	Y/E	2587.1^{**}
H×L	4	22.47	$\sigma e^2 + rK^2HLY + ryK^2HL$	HL/HLY	$3.3^{N.S.}$
H×Y	1	0.32	$\sigma e^2 + rlK^2HY$	HY/E	$2.9^{N.S.}$
L+Y	4	96.08	$\sigma e^2 + rhK^2LY$	LY/E	225.7^{**}
H×L×Y	4	18.72	$\sigma e^2 + rK^2HLY$	HLY/E	22.9^{**}
Error (E)	57	3.43	σe^2		

C.V. = 2%

$^{+}$, *, ** = Significant at the 0.1, 0.05 and 0.01 levels of probability, respectively.

N.S. = Not significant.

The seed vigour of 1982 could be considered much better than that of 1983 owing to the weather conditions. However, relative differences between the two hybrids were consistent in both years, as indicated by an insignificant (hybrid×year) interaction. In other words, there was no indication of (hybridx×year) interaction. Conversely a highly significant year effect was found. Regarding the highly significant interaction of (location×year) and (hybrid×location×year), this indicates the importance of determining the seed vigour of hybrid maize at several locations over a few years, to overcome such complicated interactions. In general this can explain the contradictory data on seed vigour through the relative magnitude of variance components for the studied variables.

The means of germination percentage of cold test (seed vigour) for the two hybrid seeds, at five locations during the two years, are presented in Table 3. It is obvious that the seed vigour varied significantly from season to season and from one location to another and responded to the change in the environmental conditions. Since the seed vigour reached its maximum value at the location of Mezőfalva, the minimum appeared at Hódmezővásárhely in both 1982 and 1983. However, drought stress in the 1983 season had significantly depressing effects at the Törökszentmiklós, Hidashát and Hódmezővásárhely locations. The stress environment is defined as the one in which mean performance for a certain attribute is low. Consequently, it may be concluded that the environment of Mezőfalva and Bóly could be considered as non-stress environments, whereas the other locations can be considered as stress environments for the seed vigour of the hybrids used. In addition, when considering the seed

Table 3

Means for percentage germination of cold test for maize hybrid seeds measured in the year of 1982 and 1983 at five locations of Middle and South Hungary

Hybrid	Cropping Year	Location					Grand mean
		Mezőfalva	Törökszent-miklós	Hidashát	Hódmező-vásárhely	Bóly	
	1982	97.2^{a*}	92.3^{cd}	91.3^{cde}	90.8^{def}	92.3^{cd}	92.8
Pi 3901	1983	97.3^{a}	86.3^{gh}	86.5^{gh}	84.0^{h}	93.8^{bc}	89.6
Sc	Mean	97.3	89.3	88.9	87.4	93.0	91.2
	1982	96.8^{a}	89.8^{def}	90.3^{def}	89.5^{rf}	93.3^{c}	91.9
Pi 3732	1983	96.0^{ab}	88.3^{fg}	85.0^{h}	75.5^{j}	96.0^{ba}	88.2
Sc	Mean	96.4	89.0	87.6	82.5	94.6	90.0
Mean	1982	97.0	91.0	80.8	90.1	92.8	92.3
	1983	96.6	87.3	85.8	79.8	94.9	88.9
Grand mean		96.8	89.1	88.3	84.9	93.3	90.6

* Followed by the same letter are not significantly different at the 5% level of probability (LSD = 2.6)

$LSD_{0.05\%}$ for (Location) = 1.3 $LSD_{0.05\%}$ for $(L \times Y) = 1.9$
$LSD_{0.05\%}$ for (Year) = 1.2 $LSD_{0.05\%}$ for $(Y \times H) = 1.2$
$LSD_{0.05\%}$ for (Hybrid) = 1.2 $LSD_{0.05\%}$ for $(H \times L \times Y) = 2.6$

vigour for each year, it was observed that no apparent significant difference occurred between the two hybrids within each location. Hence, the results of *Pi* 3901 *Sc* was equal or somewhat greater than of *Pi* 3732 *Sc* everywhere except at the Bóly location, where *Pi* 3901 *Sc* was less, and (hybrid × location) interaction was insignificant. On the other hand, there was a significant difference between the two years, since the seed vigour was lower in the 1983 crop year. Moreover, the range of the seed vigour variation was greater under the drought stress in 1983 than under the normal conditions of the 1982 season. The hybrids, within each year, were not significantly different, due to insignificance of (hybrid × year) interaction.

The drought stress during the 1983 season caused significant reduction of the seed vigour at different stages of growth in comparison with the normal conditions of the 1982 season (Fig. 1 and Table 3). The drought during the growing season substantially reduced the seed vigour for most locations, but did not significantly affect the Mezőfalva and Bóly locations. Which was probably due to the simulated rainfall by a sprinkler in these latter regions. In general seed vigour is significantly lower in a dry year than in a year of adequate rainfall (Fig. 3). It is evident that the vigour response was substantially different among the locations in 1983, and differed slightly from one location to another in 1982. High temperature may also reduce the seed vigour

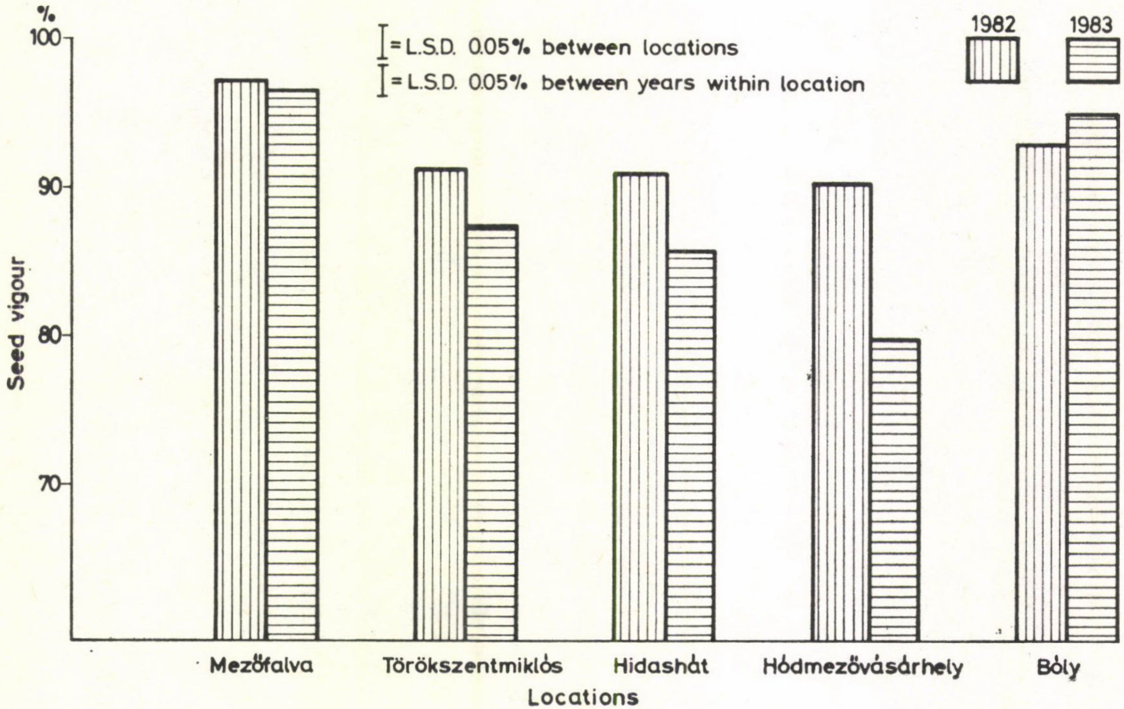

Fig. 3. Means of cold test percent for maize seed produced in 1982 and 1983 at five locations of Middle and South Hungary

by accelerating the leaf senescence and shortening the period from flowering to harvest. Furthermore, temperature affects the growth in many ways, from root growth, nutrient uptake, and water absorption to photosynthesis, respiration and translocation of photosynthetic products. Nevertheless, the intermediate precipitation produced large seeds. However, it was assumed that yields under well-watered conditions could be increased, if the seeds were completely filled. Thus, these data support those reported by Horner and Frey (1957), Laing et al. (1966) Bekendam (1975), and Campbell and Lafever (1977).

Additionally, cold tolerance (the ability of a genotype to emerge from the soil and to grow vigorously afterward in cold soil and air temperature) is a trait that should be considered important for maize breeding programs in cool areas. In this respect, Mock and McNeill (1979) found that the seedling's cold tolerance was not associated with the vegetative vigour of juvenile plants, the flowering date, or the mature plant height, indicating that good seedling vigour was related to high grain yield. On the other hand, they noted that cold tolerance response was not generally related to the geographical location of adaptation. Consequently, it should be possible to develop suitably tolerant genotypes adapted to all latitudes of maize growing through a seed improvement programme. The results obtained here revealed that he maize seed vigour was highly affected by the change of weather from one season to another more than the effect of locations. Nevertheless, the interaction between macro-environmental variables was very effective on the seed vigour trait.

Clearly, it could be proposed that climatic conditions (precipitation and temperature) during the seed development and the postmaturation-preharvest period have a great influence on the quality of seed harvested. Rare or frequent rainfall combined with high temperature resulted in rapid losses of the viability and vigour of seed in standing plants of maize. In conclusion, the climatic components of environmental are probably the most important determinants in the location of maize seed production. Complications may arise due to the genotypes which respond differently to the change of those environmental conditions that influence the physiological status of the plant, especially during its seed development. Accordingly, maize hybrid seeds must be tested for their seed vigour in different locations over several years, where they can be adapted to the production locations, to achieve the target population and the maximum yield.

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Acta Agronomica Hungarica 37 (3—4), pp. 227—231 (1988)

EFFECT OF THE EXTENT AND TIMING OF PRUNING ON THE YIELD OF RASPBERRIES AND ON THE MASS OF THE BERRIES

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(Received 10 April 1986; accepted 27 October 1986)

The effect of pruning on the yield of raspberries was influenced to a considerable extent by the extent and timing of pruning. A reduction in yield was observed when the canes were pruned drastically or at a later date. More intense pruning resulted in an increase in the mass of the berries. Less intense pruning (16% of the total cane length) carried out in early spring did not lead to yield reduction. In fact, pruning in late December significantly increased the yield compared to the unpruned control.

Keywords: raspberry, height of pruning, timing of pruning

Introduction

In order to facilitate plant cultivation and harvesting operations, it is advisable to cut back the tops of raspberry canes. From the point of view of picking and cultivation, the optimum height is around 1.6 m, but when determining the extent of pruning the condition of the plants cannot be ignored. Stronger canes should be pruned to 1.8–2.0 m, while weaker canes can be pruned to 1.4–1.5 m.

Several authors have studied the connection between the intensity of pruning and the quantity of yield; and it has been found that, the more drastic the pruning, the greater the reduction in yield (Brierly 1931, Lott 1931, Wood et al. 1961, Martin et al. 1980, Terretaz 1981, etc.). In contrast to this generally accepted view, moderate or slight pruning does not always result in yield reduction (Johnston and Loree 1927, Kollányi 1975). In fact, in some cases the yield rose compared to the unpruned control (Popov and Ivanov 1970, Rebandel and Przysiecka 1981). These latter data prove that the effect of pruning on the yield is not purely a function of the number of fruit buds removed. Pruning results in an increase in the mass of the berries (Brierly 1931, Hill 1960, Kollányi 1975), in the number of flowers and fruit per cluster (Kollányi 1975, 1978, Rebandel and Przysiecka 1981, Redalen 1981) and in the number of fruit buds which sprout (McDaniels 1922, Kollányi 1975, Rebandel and Przysiecka 1981).

Favourable changes in the yield components can compensate to a certain extent for the yield loss caused by the removal of some of the fruit buds.

The current experiments were intended to investigate the effect of earlier or later pruning dates on the result of pruning.

Material and methods

The experiment was carried out in Fertőd in a stand of Malling Exploit raspberries grown with a row distance of 2 m trained on a trellis system. The plants were in a moderately good condition. The length of the canes varied between 1.5 and 1.8 m, with an average of 1.67 m. The experiment was continued for three years in five replications on plots 16 m in length. An average of 200 canes were left on each plot. The yield of the unpruned control plots was 13.2 kg, equivalent to a per hectare yield of 4.12 t. The canes were pruned in mid-December, then prior to sprouting in mid-February and early March, and during sprouting in mid-March. In a bifactorial split-plot design, intense, moderate and weak pruning was carried out at each pruning date, and an unpruned control was also left. Weak pruning involved cutting back to a length of 1.4 m, moderate pruning to 1.0 m, and intense pruning to 0.6 m; respectively an average 16%, 40% and 64% of the total cane length was removed. The mass of the berries was determined on the basis of three measurements per plot, carried out at the beginning, in the middle and at the end of ripening.

The data were analysed on the basis of the bifactorial split-plot design and the control by means of variance analysis (Sváb 1973).

Results

Significant differences were found in all three years at the $P_{0.1\%}$ level for the quantity of yield, and at the $P_{1\%}$ level in two years and at the $P_{5\%}$ level in one year for the mass of the berries, between variants pruned to different extents. The difference between the yield averages of plots pruned at different dates was significant at the $P_{1\%}$ level in two years and at the $P_{5\%}$ level in one year. The effect of pruning date on the mass of the berries was only significant, at the $P_{5\%}$ level, in one year.

When comparing the yields of canes pruned to different heights, it can be seen that the yield decreased as a function of the intensity of pruning. Compared to weakly (1.4 m) pruned canes, however, the yield of moderately and intensely pruned canes decreased to a lesser extent than the length of the cane, despite the fact that fruit buds were more densely placed on the parts removed than on those remaining (Table 1a).

An opposite effect could be observed for the mass of the berries. The more intense the pruning, the greater the mass of the berries (Table 2). The increased mass of the berries compensated to some extent for the yield loss resulting from the reduction in the number of fruit.

The effect of pruning also changed consistently as a function of the pruning date. The later the pruning was carried out, the greater the reduction in

Table 1

Effect of intensity and date of pruning on yield per cane (3-year average)

(a) Yield reduction as a function of pruning intensity
Weak pruning (1.4 m) = 100%

Pruning intensity, m	Pruning date				Averaged over pruning dates	
	Dec. 9	Feb. 16	March 2	March 15	%	g/cane
1.4	100.0	100.0	100.0	100.0	100.0	66
1.0	87.6	89.7	90.4	90.0	89.3	59
0.6	63.0	60.2	55.5	51.6	57.5	38
$LSD_{5\%}$					5.6	3.7

(b) Yield reduction as a function of pruning date
December pruning = 100%

Pruning date	Pruning intensity, m			Averaged over pruning intensity	
	1.4	1.0	0.6	%	g/cane
Dec. 9	100.0	100.0	100.0	100.0	61
Febr. 16	93.1	95.3	89.2	92.5	56
Mar. 2	86.3	89.0	76.0	83.7	51
Mar. 15	82.1	84.3	67.4	77.9	48
$LSD_{5\%}$				4.9	3.0

(c) Yield as a % of the unpruned control
Average length of unpruned canes: 1.67 m

Pruning intensity, m	Pruning date			
	Dec. 9	Feb. 16	March 2	March 15
1.4	114.0	106.2	98.4	93.7
1.0	100.0	95.3	89.0	84.3
0.6	71.8	64.0	54.6	48.4

$LSD_{5\%}$ = 9.1% between any two treatments

yield. The yield of canes pruned in mid-March was 18–33% lower than that of canes pruned in December (Table 1b).

The effect of the pruning date on the mass of the berries was insignificant, but the tendency of late pruning to have an unfavourable effect could be observed in all three years.

The effect of the intensity and date of pruning on the yield was also studied in comparison with the unpruned control. The unfavourable effect of

Table 2

Effect of intensity and date of pruning on the mass of the berries (g) (3-year average

Height of pruning, m	Unpruned control ∅	Pruning date				Pruning intensity
		Dec. 9	Feb. 16	March 2	March 15	x̄
Unpruned ∅ 3.8						
1.4		3.9	3.8	4.0	41.	3.9
1.0		4.1	4.2	4.3	4.4	4.2
0.6		4.6	4.8	4.9	5.0	4.8
Pruning date x̄		4.2	4.3	4.4	4.5	

$LSD_{5\%}$ = 0.32 between any two combinations
$LSD_{5\%}$ = 0.17 between the averages of pruning intensity
The difference between the pruning date averages was insignificant.

pruning was significant when pruning was carried out late. Weak pruning in early spring did not lead to yield reduction; in fact, weak pruning in December increased the yield, compared with the unpruned control (Table 1c). Even the latest pruning, carried out at the most unfavourable time, did not reduce the yield to an extent equal to the reduction in cane length.

The yield loss resulting from the removal of some of the fruit buds can be compensated for in raspberry plants to some extent by favourable changes in other yield components. The earlier pruning is carried out, the greater effect it will have on the development of new flowers and fruit, and on the sprouting of dormant buds. At sprouting, pruning has hardly any stimulatory effect, since the differentiation of the fruit buds is complete by this date. this is no doubt the reason why pruning at a late date led to a substantial reduction in yield, compared with the unpruned control.

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Acta Agronomica Hungarica 37 (3—4), pp. 233—237 (1988)

EFFECT OF HARVEST FREQUENCY ON YIELD AND QUALITY OF SORGHUM×SUDANGRASS HYBRID

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(Received 20 June 1985; accepted 20 October 1986)

The relationship between the growth rate and the cumulative dry matter crude protein, crude fibre yield — as influenced by cutting frequency — was examined for the Sorghum X Sudangrass hybrid, "Bovital". The seasonal distribution and amounts of dry matter during the period of 140 days from sowing to maturity, and the chemical composition of the plants, were closely related to plant height and cutting management.

Keywords: Sorghum sp., Sudangrass, hybrid "Bovital", dry matter distribution

Introduction

Increasing attention for forage use of species in the sorghum genus calls for additional information on productiviy of this cultivar in the case of different management technologies.

Burns, Wedin (1964) found that the pasture-stage cut (40–50 cm) yielded considerably less than the haystage cut (early bloom stage). Worker, Marble (1968) studied the digestibility of different stages of Sorghum×Sudangrass hybrid and found that the maturation brings progressive changes in chemical composition. Edwards et al. (1971) found that the digestible dry matter of the Sorghum×Sudangrass hybrid, Sudax Sx-11, decreased from 90% when plants were 30 cm high to less then 60% when plants were 250 cm high, and remained relatively constant for 6 weeks after panicle emergence.

Similar data were reported by Józsa (1976) in Hungary, studying a three-way cross Sorghum-Sudangrass hybrid; "Hybar Mv 301."

Material and methods

Experiments were conducted in 1981 to study the growth rate and chemical composition of the Sorghum×Sudangrass hybrid, "Bovital". The plots were sown on May 7th at Karcag, 68 kg N per hectare as ammoniumnitrate and 90 kg P_2O_5 per hectare as superphosphate were applied as basal dressing, while 17 kg N per hectar were applied after the second and third cuts. A modified splitplot treatment in a randomized block design, with four replications of the main treatments, was employed. In the first management, plants were not cut back; in the second management, plants were cut back to a 10 cm stubble when they reached the early boot stage; and in the third, plants were cut back to a 10 cm stubble whenever they reached 80 cm. Each plot was divided into 15 units.

Table 1

Green matter yield, dry matter, crude protein and crude fibre percentage as affected by plant growth of "Bovital" (Sorghum × Sudangrass hybrid)

Days after sowing	1 cut/year				2 cuts/year				3 cuts/year			
	Yield, kg/10 m²	Dry matter %	Crude protein %	Crude fibre %	Yield, kg/10 m²	Dry matter %	Crude protein %	Crude fibre %	Yield, kg/ 10m²	Dry matter %	Crude protein %	Crude fibre %
30	2.2	18.6	21.6	24.1	2.4	16.6	24.1	25.2	2.4	22.4	24.3	25.6
40	9.7	17.9	18.3	24.3	10.5	17.1	22.6	24.6	10.7	16.7	20.6	23.8
50	15.5	18.2	20.8	26.4	20.8	17.4	20.3	21.2	20.8	14.5	19.8	26.4
60	22.9	17.4	19.6	28.9	33.0	16.7	19.2	20.9	33.8	16.6	19.5	29.9
70	37.3	18.6	18.5	30.3	37.8	14.3	17.5	27.9	2.8	24.6	21.7	24.3
80	46.0	18.6	17.1	31.8	54.9	16.2	12.6	23.3	17.0	18.5	19.6	24.7
90	49.6	21.7	15.7	33.7	2.4	17.3	24.7	24.3	33.2	12.7	18.7	27.3
100	51.9	24.2	14.1	32.9	9.4	16.2	20.3	24.8	2.0	20.5	203.	24.2
110	53.3	29.6	12.3	33.8	15.5	17.5	19.1	26.4	6.8	22.5	19.7	26.8
120	43.9	32.7	10.6	34.7	29.6	15.6	17.6	29.3	23.4	14.5	18.6	26.3
130	52.9	33.4	9.3	37.1	46.1	18.3	16.2	28.5	29.5	15.6	17.8	28.4
140	48.9	34.3	8.3	39.2	50.6	15.7	14.3	31.9	38.2	14.8	17.5	28.9

Table 2

Effect of harvest frequency on forage yield and quality characteristics of "Bovital" (Sorghum × Sudangrass hybrid)

	1 cut/year				2 cuts/year			3 cuts/year		
	Leaf	Stem	Grain	Whole plant	Leaf	Stem	Whole plant	Leaf	Stem	Whole plant
Green yield, kg/10 m^2	10.9	34.3	3.7	48.9	76.3	29.2	105.5	43.5	51.7	95.2
Dry matter (%)	42.1	29.9	74.8	34.3	13.5	22.2	15.9	18.1	12.6	15.1
Dry matter yield, kg/10 m^2	4.59	10.26	2.77	16.77	10.28	6.49	16.78	7.86	6.54	14.4
Crude protein (%)	10.8	5.5	12.0	8.3	10.2	17.5	13.0	19.3	17.8	18.6
Crude protein yield, kg/10 m^2	0.496	0.563	0.332	1.391	1.049	2.184	2.184	1.517	1.165	2.682
Crude fibre (%)	34.7	48.5	—	39.2	26.4	30.8	29.1	26.7	30.5	28.4
Crude fibre yield, kg/10 m^2	1.593	4.991	—	6.574	1.713	3.169	4.882	2.098	1.996	4.094

One unit was 1.2 m vide, 5 m long and consisted of four rows. On both sides of the plot was an unplanted row for border protection. The plot was harvested at intervals of 10 days. A sample, of 50 tiller, was separated to component parts: stems, leaves and seeds. The leaf coller and inflorescences were included in the leaf portion. The panicle was defined as stem. Samples were air dried, for crude protein and crude fibre determinations.

Results

The yield data of dry matter, crude protein, crude fibre per cent of Bovital Sorghum × Sudangrass hybrid for the three cutting managements are presented in Table 1. The green matter yield increased significantly in the first 80 days from sowing, until the boot stage of maturity. From this stage onward the dry matter per cent increased, causing a significant increase in the dry matter yield.

From the soft dough stage of maturity the green yield decreased. The crude fibre content increased and the crude protein content decreased as harvest was delayed. The most marked decrease in crude protein was noted from the boot stage of maturity.

As harvest frequency decreased in this experiment, the mean crude protein content dropped from 18.6% to 8.3%.

In the case of single yearly harvest, the green matter yield was significantly less than in the case of multiple harvest. A significant decrease in dry matter yield is shown as harvest frequency increased (2 and 3 cuts yearly). (Table 2.).

The Sorghum × Sudangrass hybrid, Bovital, yielded significantly less dry matter when harvested 3 times yearly.

Crude protein yields differed significantly in the applied management techniques. A significant increase in crude protein content could be observed as harvest frequency increased; 1391 kg/ha, 2184 kg/ha, 2682 kg/ha respectively in case of one, two, and three cuts/year.

As harvest frequency decreased from three cuts to two cuts, the crude fibre yield increased from 4094 kg/ha to 4882 kg/ha. The highest crude fibre content (38.2%) and yield (6574 kg/ha) were observed in the case of single harvest.

Discussion

Sorghum × Sudangrass hybrids have the potential to produce a large amount of highly digestible forage. It is recognized that the forage production and the quality characters are related to management technology.

Investigations have shown how the cutting systems that remove immature panicles and terminal or auxiliary meristems result in poor subsequent regrowths and low late-season production. Previously uncut plants produced about 17 t/ha dry matter during a period of 140 days from sowing until maturity. The dry matter yield was significantly lower in the case of 3 cuts per year.

The chemical composition of the plant was closely related to plant height and cutting management; but crude fibre content apparently related more to age of plant and to proportion of leaves and stem, than either to amount of regrowth or to cutting management. In general the crude fibre content increases as long as the proportion of the stem dry matter increases.

The crude protein content of the plant increased as the harvest frequency increased. Considering the ranking of management techniques based upon the yield of crude protein in relation to dry matter and crude fibre yield, the management height in yield and dry matter tends to be lower in crude protein percentage and crude protein yield. This was very evident under the third management technology, where plants were cut back to 10 cm stubble each time that they reached 80 cm height.

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Acta Agronomica Hungarica 37 (3—4), pp. 239—243 (1988)

UPTAKE OF NITROGEN IN DIFFERENT GROWTH PHASES OF RICE THROUGH *AZOLLA* BIOFERTILIZER

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Two field experiments were conducted during the early and late wet seasons (1984–85) in Tamil Nadu Agricultural University, Coimbators, India, to study the effect of *Azolla* biofertilizer on the uptake of nitrogen in different growth phases of rice. *Azolla* as dual culture, green manure, 75 kg N through different forms of urea, with *Azolla* inoculation as dual culture, comprised the treatments. Plant samples were taken at different growth phases, the N content was analysed and the uptake of N was computed. All the treatments recorded higher uptake of N than the control. Plots treated with 75 kg N as Neem coated urea (NCU) + *Azolla* (DC) recorded highest uptake of N during harvest stage in early wet season and also at 75th day and harvest stage in late wet season. Uptake was higher in the late than in the early wet season.

Keywords: rice, *Oryza sativa* L., *Azolla* sp., biofertilization, nutrient uptake

Introduction

Azolla is a water fern known to exist in intimate association with the cyanobacterium — *Anabaena azollae* which is capable of fixing nitrogen from the atmosphere (Peters, 1975) and is widely used as a potential biofertilizer in increasing the grain yield of rice (Kannaiyan, 1981). The utilization of *Azolla* as biofertilizer for rice crop has been well established in recent years (Kannaiyan, 1985; Liu Chung Chu, 1979 and Watanabe, 1985). Watanabe et al. (1977) found that *Azolla* fixed about 1.13 kg N ha^{-1} day $^{-1}$. The use of *Azolla* as green manure and also as dual cropping with rice has been well documented by Lumpkin and Plucknett (1980). Srinivasan (1980) found that *Azolla* inoculation as dual culture with rice at 3 t ha^{-1} gave a yield increase equal to that of 25 kg N ha^{-1}. Liu Chung Chu (1979) reported an increase of 18.6% rice yield due to *Azolla* application. The present field experiments were conducted to study the effect of fertilizer nitrogen and *Azolla* application on the uptake of nitrogen in different growth phases of rice.

Material and methods

The field experiments were conducted in Tamil Nadu Agricultural University, Coimbotore, India, during the early wet season (November–March) 1984–85 to study the effect of fertilizer nitrogen and *Azolla* application on the uptake of nitrogen in different growth phases of rice. Experiments were laid out in randomised blocks with four replications. The treatments applied were (i) control, (ii) *Azolla pinnata* (R. Brown) as dual crop at 200 g m^{-2}, (iii) *Azolla* as green manure (10 t ha^{-1}, (iv) 75 kg N as prilled urea (PU) + *Azolla* (DC), (v) 75 kg N as urea super granula (USG) + *Azolla* DC (vi) 75 kg N as NCU + *Azolla* (DC), (vii) 25 kg N as PU + 25 kg N as USG + 25 kg N as NCU + *Azolla* (DC). *Azolla* at 10 t ha^{-1} was applied as green manure and incorporated before planting. For dual cropping, *Azolla* at 200 g m^{-2} was inoculated one week after the transplanting of rice. Nitrogen as prilled urea was applied in two split doses, half as basal and the remaining half at 20 days after transplanting in the early wet season, and 40 days after transplanting during the late wet season. Urea super granule was placed at 10 cm depth between 4 hills of rice plants. Neem coated urea was prepared from neem cake by mixing 20% (w/w) neem cake powder with prilled urea, and was shade dried for three hours before application. Neem cake is the residue obtained from the dried fruits of neem tree *(Azadirachta indica)* after oil extraction.

In the early wet season, IR–50 seedlings were transplanted with a spacing of 15×10 cm. However, in the later wet season, CO–43 seedlings were transplanted with a spacing of 20×10 cm. Plant samples were taken on 45th, 75th days after sowing and at harvest stage. Nitrogen content of the plant samples were estimated by micro-Kjeldahl method (Yoshida et al., 1972) and the uptake of N was computed by multiplying the N content with the respective dry matter production, and expressed in kg ha^{-1}.

Results

The dry matter production, the uptake of N and the yield in *Azolla*-applied plots during the early and late wet seasons are presented in Tables 1, 2 and 3.

Between the 45th day and at the 75th day dry matter production was greater in the early wet season, while at harvest dry matter production was greater in late wet season. At the 45th day, plots treated with 25 kg N each as PU, USG, N CU besides *Azolla*, as dual crop, recorded highest uptake on N during early wet season; and plots treated with 75 kg N as N CU + *Azolla* (DC)

Table 1

Effect of fertilizer nitrogen and Azolla on the dry matter production in different growth phases of rice
Coimbatore, India (1984–85)

Treatments (N kg ha^{-1})	Dry matter production (t ha^{-1})					
	Early wet season (IR–50)			Late wet season (CO–43)		
	45th day	75th day	At harvest	45th day	75th day	At harvest
Control	0.85	2.60	5.64	0.48	1.32	8.00
Azolla (DC) 200 g m^{-2}	0.97	3.27	6.94	0.61	1.30	8.79
Azolla (GM) 10 t ha^{-1}	1.09	3.44	6.95	0.68	1.73	8.78
75 as PU + *Azolla* (DC)	1.17	4.32	8.87	0.76	1.59	11.58
75 as USG + *Azolla* (DC)	1.47	4.22	9.49	1.02	2.15	11.56
75 as NCU + *Azolla* (DC)	1.60	4.37	9.28	0.96	2.44	12.03
25 as PU + 25 as USG + + 25 as NCU + *Azolla* (DC)	1.47	4.12	9.75	0.92	2.05	12.10
LSD $_{P=0.05\%}$	0.2	0.3	0.8	0.2	0.5	1.2

Table 2

Effect of fertilizer nitrogen and Azolla on yield of rice
Coimbatore, India (1984–85)

Treatments (N kg ha^{-1})	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	Early wet season (IR–50)	Late wet season (CO–43)	Early wet season (IR–50)	Late wet season (CO–43)
Control	2269	3218	3140	5003
Azolla (DC) 200 g m^{-2}	2844	3694	3809	5301
Azolla (GM) 10 t ha^{-1}	2800	3625	4092	5284
75 as PU + *Azolla* (DC)	3912	4932	4704	6368
75 as USG + *Azolla* (DC)	4347	4817	4812	6515
75 as NCU + *Azolla* (DC)	4232	5128	4724	6589
25 as PU + 25 as USG + + 25 as NCU + *Azolla* (DC)	4358	5055	4679	6389
LSD $_{P=0.05\%}$	258.7	205.0	409.1	310.8

Table 3

Effect of fertilizer nitrogen and Azolla on the nitrogen uptake in different growth phase of rice
Coimbatore, India (1984–85)

Treatments (N kg ha^{-1})	N uptake (kg ha^{-1})							
	Early wet season (IR–50)				Late wet season (CO–43)			
	45th	75th	At harvest		45th	75th	At harvest	
	day		Grain	Straw	day		Grain	Straw
Control	20.7	34.6	18.2	18.4	8.8	16.9	30.0	29.9
Azolla (DC) 200 g m^{-2}	22.0	43.5	24.4	20.1	16.3	18.8	36.2	58.1
Azolla (GM) 10 t ha^{-1}	30.9	51.8	24.4	21.6	16.6	16.6	35.5	64.1
75 as PU + *Azolla* (DC)	29.0	60.4	32.9	29.6	34.2	334.2	49.8	43.1
75 as USG + *Azolla* (DC)	41.9	54.7	38.3	32.6	32.1	32.1	50.4	76.0
75 as NCU + *Azolla* (DC)	41.9	49.0	36.8	34.8	38.6	38.6	51.3	76.9
25 as PU + 25 as USF + + 25 as NCU + *Azolla* (DC)	45.9	52.0	38.4	32.8	37.4	37.4	51.6	76.0
LSD $_{P=0.05\%}$	4.8	4.4	2.1	7.1	2.9	14.7	1.8	4.0

recorded highest N uptake in the late wet season. However, on the 75th day plots that received 75 kg N as PU + *Azolla* (DC) recorded highest uptake of N (60.4 kg ha^{-1}) in the early wet season. Plots treated with 75 kg N as N CU + + *Azolla* (DC) recorded highest uptake of N at harvest stage in the early wet season, and at harvest stage in late wet season. The uptake of N was very low in control plots. The uptake of N during the 45th and the 75th day after sowing was comparatively less in the late wet season. However, the uptake trend was significantly higher at harvest period.

The application of 25 kg N each as PU, USG and N CU, besides *Azolla* as dual crop, has recorded highest grain yield in the early wet season; whereas, plots treated with 75 kg N as N CU and *Azolla* as dual crop have produced highest grain and straw yield in the later wet season. In the early wet season, plots applied with 75 kg N as USG and *Azolla* as dual crop registered higher straw yield.

Discussion

Increased dry matter production might be due to the continuous supply of N throughout the growth period when resulted in better vegetative growth. Highest uptake of N in plots which have received 75 kg N as PU + *Azolla* (DC) in the early wet season might be due to the split application of prilled urea which resulted in reduced loss of N and increased availability to the crop. Shivaradj (1981) found higher grain yield in rice due to *Azolla* application. Azolla N was found to be slowly released but gradually available to rice plants (Singh et al., 1981). The possible reasons attributed for higher N uptake in plots received 75 kg N as N CU + *Azolla* (DC) are the inhibition of nitrification by neem cake and better availability of N after decomposition of *Azolla*. The combination of urea with *Azolla* enhanced the mineralization and the availability of N was found to be rapid. The present results are in accordance with the findings of Shankar et al. (1976) who found significant increase in uptake by blending urea with 20% neem cake. Subbaiah et al. (1979) stated that uptake of N in grain and total N uptake in N CU treatment were significantly superior to that of split application of N as prilled urea.

Uptake of N was higher in the late than in the early wet season. This might be due to the higher dry matter production during the late wet season. In the late wet season plant population per unit area was less and the dry matter accumulation was also low in early stages; and during subsequent crop period the dry matter accumulation was significantly more. This might be one of the reasons for more uptake of N during the late than the early wet season. Moreover, the *Azolla* biomass produced was also more in the late wet season due to the low temperature at that period. In the late wet season *Azolla* biomass was incorporated thrice, while in the early wet season only two incorporations were done. The availability of N from *Azolla* might be slow and steady in the late wet season, since there was sufficient time for decomposition. This might be the reason for higher N uptake in late wet season. Incorporation of *Azolla* to soil significantly increased the C : N ratio which activated the microbial proliferation and the consequent immobilization of available N (Nandabalan, 1984). However, after 4 and 8 weeks a significant amount of available N was released because of the active decomposition of added *Azolla*.

The dry matter production was very low in the control plots and the growth of the plants was also poor due to the non-availability of nitrogen to the plants. The results have shown that the application of Azolla as biofertilizer for rice was effective in increasing the nitrogen uptake and yield of rice.

Acknowledgement

The senior author is thankful to the Ford Foundation for the financial assistance rendered during the investigation.

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Acta Agronomica Hungarica 37 (3—4), pp. 245—255 (1988)

EFFECT OF FERTILIZATION OF CHANGES IN THE MICROELEMENT CONCENTRATIONS OF *TRITICALE* DURING VEGETATION

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(Received 30 June 1986; accepted 20 July 1986)

In a NPK fertilization field experiment set up on slightly humous calcareous sandy-soil changes in the B-, Ba-, Be-, Bi-, Sn-, Sr-, Sb-, Te-, Ti-, Se-, V-, As- and Hg concentrations of Triticalle-winter crop — were followed in the total aboveground part during vegetation. Plant samples — the total aboveground part of 4 running metres on each of 10 occasions — were generally taken every 10 days. The concentrations in the plant material were determined using an ICP apparatus following a hydrochloric acid hydrolysis. The results can be summarized as follows:

— Maximum concentrations of the elements examined — except B, Ba and Sr — were measured in an early stage of development (Feekes 2, 4), in the phase of tillering.
— Changes in the concentrations — except in those of B, Ti, Sb, Hg and Se — during vegetation up to the phenophase of milky ripeness were generally characterized by a decreasing tendency.
— In full maturity the concentrations of Sn, As, Hg and Se were higher in the grain, while the other elements were found at higher concentrations in the straw.
— Macroelement (NPK) nutrition resulted in changes of concentrations statistically demonstrable for all elements examined except for Te, Ti, Se and Sb on most dates of sampling.
— In the nutrition treatments the increase in concentration was measured for Sr on each date and for the other microelements on most dates of sampling.
— In some dates of sampling (1–4.) a significant decrease in concentration in response to fertilization was measured, except for Sr and Ti.
— With the exception of B, Be, Ti and Se, nutrition caused significant changes in the microelement concentrations of the grain, and within this an increase in concentration of each of them, except Sb, V and As.
— As for the straw, fertilization resulted in significant concentration changes in all the elements examined, and within this an increase in concentration except of Bi, Sn, Hg and Sb.

Keywords: *Triticale*, NPK fertilization, concentration dynamics of microelements, vegetation period.

Introduction

The microelements are discussed according to their occurrence in the living organisms. This does not, however, mean that their biological importance is always the same.

The microelements are of specific ecological, biological and sanitary importance. Despite the fact that the basic rules of biochemistry are the same for all living organisms, some microelements may be important for the plant life alone, others for the functions of animal life. According to Pais (1980) "In respect of the microelements soil, plant and man can only be considered as a whole".

The microelements represent a negligible proportion in the chemical composition of the soil, while they are at the same time indispensable as plant nutrients. The presence of microelements has little relation to the basic rock, their distribution in the soil is connected with various processes of soil formation and with other external impacts (agricultural production, contamination, etc.).

The microelement composition of the plant is generally influenced by the composition of the surrounding medium. Consequently, the elements composing the Earth probably can be found in the plants (Epstein 1972, Kastori 1983, Pais 1980).

It is a well-known fact that the concentration — first of all of elements indispensable for the plants is not a constant value; under the influence of internal genetic- and external — mainly edaphic and climatic — factors, further as a function of the vegetation period it changes within relatively wide limits (Bowen 1979, Chapman 1972, Epstein 1972, Kastori 1983). The biological and nutritional aspects of the role and importance of microelements in the living organisms form a special field of research on which many a monograph has been written.

Lately a new branch of science — bioinorganic chemistry — has emerged. It is concerned with the reactions of elements and ligands with proteins, nucleic acids, hormones, vitamins etc. on a molecular level (Kőrös 1980). The application of the most up-to-date physical and chemical methods in the field of biology and chemistry bears particular importance for the development of this science.

A system based on the modern interpretation of the acid-base reactions (Pearson 1968), as well as the metal ion classification system of the linkage of elements and ligands based on covalent and ionic indexes (Nieboer and Richardson 1980) have been elaborated.

Besides the nutritive elements, other microelements of *Triticale* were also examined for changes in concentration during vegetation, in order to obtain information on the trend of changes and their relation with intensive nutrition.

The experiment was intended to supply data on changes during vegetation in the concentrations of essential, as well as potentially contaminating, elements in agricultural crops given intensive nutrition.

Material and methods

The fertilization experiment was set up at Őrbottyán, on the trial grounds of the Institute of Soil Science and Agrochemisty of the Hungarian Academy of Sciences, in the autumn of 1980, with *Triticale* (variety: KT–77) as an indicator plant, arranged in random block design with 4 replications. In the treatments various combinations of NPK were used (Table 1). Plant samples — the total aboveground part from 4 running metres of each plot — were taken on 10 occasions, every 10 days in general.

After the preparation of the samples, extraction was carried out in closed space with 3 normal hydrochloric acid hydrolyses (Varju and Zsoldos 1974). Measuring was performed in the NAÁ Laboratory of Hajdú-Bihar Country using an ICP apparatus. Here we express our thanks to the workers of the Laboratory for their assistance in the determination work.

In the biometric evaluation, variance analysis was applied. Of other circumstances of the experiment, accounts were given in previous publications (Lásztity 1986a, b).

Results

Boron is one of the microelements indispensable for plants. The cereals belong to plants with a moderate demand for B (Sikora 1974). In the *Triticale* plants examined, the boron content (Table 1) showed a high fluctuation in the course of the vegetation period, reaching maximum at the beginning of flowering followed by a gradual decrease until the end of vegetation.

Table 1

Effects of fertilization and vegetation period on the boron content of Triticale (ppm)
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
1 0	10.0	31.6	28.0	14.0	9.0	60.0	10.0	8.0	3.2	0.8	5.4
2 N	9.2	22.4	18.0	20.0	8.0	56.0	16.0	8.0	3.8	0.9	8.3
3 P_1K_1	5.4	28.3	14.0	18.0	16.0	46.0	10.0	8.0	3.0	1.0	4.6
4 NP_1	5.6	27.2	18.0	36.0	10.0	54.0	28.0	8.0	3.2	1.0	3.2
5 NK_1	7.9	22.0	24.0	16.0	18.0	38.0	9.0	8.0	3.0	0.6	3.8
6 NP_1K_1	5.8	23.2	15.0	20.0	30.0	51.0	16.0	6.0	3.0	0.8	4.7
7 NP_2K_2	5.3	19.6	15.0	15.0	30.0	45.0	13.0	8.0	2.2	0.8	4.0
$LSD_{5\%}$	3.6	—	10.0	9.0	11.0	—	4.0	—	0.8	—	1.2

N = 200 kg N/ha, P_1 = 500 kg P_2O_5/ha K_1 = 500 kg K_2O/ha
P_2 = 1000 kg P_2O_5/ha K_2 = 1000 kg K_2O/ha

The lowest concentrations were found in the grain. The effect of fertilization — except on 3 sampling dates and in the grains — could not be proved. In those treatments where the effect of fertilization was statistically demonstrable, increases and decreases in concentration were equally observed.

Tin is one of the elements of partial biological importance. It occurs in small quantities in nature and has no toxic effect (Chapman 1972). *Triticale* likewise contains small quantities of it. Its concentration was the highest at the end of tillering and afterwards became continuously lower. At the stage of ripening, on the other hand, its concentration rose again (Table 2).

Table 2

Effects of fertilization and vegetation period on the microelement content of Triticale
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
					Sn (ppm)						
1 0	4.25	6.40	4.80	2.80	4.20	4.60	5.00	5.00	4.50	7.55	7.23
2 N	3.76	7.58	4.80	3.00	4.20	4.80	5.00	5.00	4.10	7.71	5.62
3 P_1K_1	2.52	5.59	4.60	2.80	3.80	4.60	5.00	5.00	4.70	7.55	5.94
4 NP	3.46	7.74	5.00	3.20	5.40	5.20	5.20	5.00	5.10	7.55	7.23
5 NK_1	3.47	7.26	2.60	2.50	4.90	4.90	4.10	4.80	4.80	7.55	5.70
6 NP_1K_1	3.23	7.17	2.40	2.80	4.80	5.00	5.00	4.30	4.60	7.63	6.26
7 NP_2K_2	3.32	6.95	2.40	2.70	5.00	4.40	5.00	4.90	4.20	7.63	6.34
$LSD_{5\%}$	1.42	—	1.80	0.30	1.20	0.30	0.20	0.50	0.50	0.08	0.44
					Se (ppb)						
1 0	—	47.1	—	16.0	42.0	30.0	34.0	66.0	—	24.4	8.6
2 N	—	59.2	—	32.0	71.0	42.0	52.0	54.0	—	25.2	7.2
3 P_1K_1	—	44.8	—	33.0	36.0	42.0	40.0	60.0	—	22.8	7.6
4 NP_1	—	59.2	—	36.0	45.0	46.0	62.0	46.0	—	23.5	9.0
5 NP_1	—	59.7	—	38.0	55.0	40.0	51.0	35.0	—	23.2	8.0
6 NP_1K_1	—	56.8	—	24.0	44.0	30.0	60.0	54.0	—	26.7	8.0
7 NP_2K_2	—	58.3	—	44.0	40.0	29.0	48.0	52.0	—	26.0	10.2
$LSD_{5\%}$	—	15.9	—	20.0	9.0	11.0	13.0	17.0	—	2.6	1.5

With the exception of a single date of sampling, the effect of NPK nutrition proved significant, though its trend was not consistent: increase and decrease in tin concentration equally appeared in the treatments.

In the grain and straw fertilization made its effect felt, by increasing the amount of tin in the former and decreasing it in the latter.

Selenium also belongs to the group of elements with partial biological importance. It has a much greater and well-known role in animal breeding and feeding (Girling 1984). It has no toxic effect on plants. Its quantity ranges between wide limits both in the soil and in the plants.

In the plants examined, the selenium content was determined in ppb (Table 2). The concentration showed a decrease with larger or smaller fluctuations; the highest concentration was measured in the phase of tillering. The effect of fertilization was statistically demonstrable on five occasions of sampling and in the straw. With a single exception, an increase could be registered, first of all in treatments representing combinations of nitrogen.

Titanium belongs to the group of non-essential and non-toxic elements. Its biological importance has been studied by a number of authors; its role in the development of plants was indicated by Pais et al. (1983). In the course of the development of *Triticale* plants, the element could be detected by this method only in some phenophases (Table 3). The highest values were obtained at the end of tillering, after which a decreasing tendency prevailed until ripening, at which point an increase in concentration took place in the straw.

Statistically demonstrable changes due to the NPK nutrition were found on a single occasion of sampling, and in the straw.

Vanadium is one of the most widespread elements in nature.Its biological importance is considered as merely partial; and in the case of higher plants, it is not reckogned among the essential elements (Welch and Cary 1975).

From the phase of tillering the concentration of vanadium gradually decreased throughout the vegetation period, apart from a slight fluctuation (Table 3). The highest concentration was found on tillering and the lowest in the stage of milky ripening.

The effect of fertilization was demonstrable on most dates of sampling; increase was generally statistically demonstrable, but in two cases and in the grains a decrease in concentration was observed. No consistent systematic effect linked to one nutritive element or another could be determined.

Table 3

Effects of fertilization and vegetation period on the microelement content of Triticale
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
					Ti (ppm)						
1 0	0.42	1.23	—	0.45	0.56	—	—	—	—	—	0.72
2 N	0.56	1.42	—	0.30	0.28	—	—	—	—	—	0.68
3 P_1K_1	0.72	1.12	—	0.64	1.48	—	—	—	—	—	1.18
4 NP_1	0.26	1.57	—	0.56	0.17	—	—	—	—	—	0.46
5 NK_1	0.24	1.48	—	0.44	0.14	—	—	—	—	—	0.58
6 NP_1K_1	0.49	1.28	—	0.50	0.22	—	—	—	—	—	0.78
7 NP_2K_2	0.53	1.20	—	0.42	0.31	—	—	—	—	—	0.70
$LSD_{5\%}$	—	0.43	—	0.20	0.54	—	—	—	—	—	0.24
					V (ppb)						
1 0	19.6	8.8	6.7	6.4	7.3	3.7	4.0	3.3	5.2	4.4	10.6
2 N	17.3	10.1	6.6	5.7	6.2	3.3	3.4	3.6	3.2	3.9	8.3
3 P_1K_1	15.3	9.3	5.8	7.0	9.6	4.8	4.0	4.8	4.4	4.1	11.4
4 NP_1	19.4	9.8	7.7	7.7	6.8	3.6	3.0	4.2	4.4	3.6	7.8
5 NP_1	21.9	10.4	6.4	5.2	5.0	4.4	2.9	4.0	3.0	3.3	7.8
6 NP_1K_1	15.3	8.9	4.9	6.0	5.8	3.0	2.9	2.0	2.2	5.0	9.6
7 NP_2K_2	19.9	9.3	5.5	5.8	6.2	3.2	3.4	2.8	2.3	3.2	9.0
$LSD_{5\%}$	6.6	—	0.7	1.0	1.5	0.5	0.3	0.9	0.6	0.9	0.8

Barium is an element of unknown biological effect, which has been examined for its interactions with other elements, first of all with calcium (Wallace—Romney, 1971). Its concentration in *Triticale* could be determined in ppm quantities on all dates of sampling (Table 4). From tillering to milky ripening its concentration was found to decrease. At the stage of maturity an intense increase in concentration occurred in the straw, partly at the expense of the grain.

Table 4

Effects of fertilization and vegetation period on the microelement content of Triticale
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
					Ba (ppm)						
1 0	30.8	40.5	28.0	16.0	23.0	14.0	26.0	28.0	30.0	9.2	91.8
2 N	31.4	41.4	25.0	16.0	18.0	14.0	14.0	18.0	20.0	9.5	82.1
3 P_1K_1	26.8	48.9	30.0	22.0	21.0	18.0	30.0	26.0	30.0	8.1	92.2
4 NP_1	24.8	41.8	25.0	28.0	22.0	16.0	15.0	16.0	28.0	7.2	97.2
5 NK_1	32.8	44.3	17.0	18.0	18.0	17.0	18.0	26.0	32.0	4.4	80.4
6 NP_1K_1	30.4	45.5	16.0	20.0	24.0	16.0	14.0	10.0	24.0	3.2	99.3
7 NP_2K_2	31.3	39.6	15.0	22.0	18.0	14.0	17.0	18.0	24.0	6.3	94.6
$LSD_{5\%}$	—	—	9.0	5.0	5.0	3.0	4.0	5.0	6.0	0.97	7.6
					Be (ppm)						
1 0	0.29	0.33	0.22	0.09	0.13	0.06	0.07	0.07	0.08	—	0.20
2 N	0.35	0.40	0.23	0.12	0.16	0.11	0.08	0.07	0.07	—	0.24
3 P_1K_1	0.23	0.32	0.20	0.10	0.12	0.08	0.06	0.08	0.06	—	0.18
4 NP_1	0.30	0.40	0.24	0.14	0.16	0.12	0.08	0.10	0.09	—	0.25
5 NP_1	0.28	0.40	0.09	0.12	0.14	0.10	0.07	0.11	0.08	—	0.22
6 NP_1K_1	0.28	0.38	0.08	0.11	0.13	0.10	0.07	0.06	0.04	—	0.24
7 NP_2K_2	0.31	0.41	0.10	0.12	0.14	0.10	0.08	0.07	0.06	—	0.24
$LSD_{5\%}$	—	—	0.11	0.03	0.01	0.01	0.01	0.02	0.02	—	0.02

On most occasions of sampling NPK nutrition was found to have caused significant changes. These changes were manifested partly in an increase, partly in a decrease of concentration. The increase was connected with the PK-, and the decrease generally, though not consistently, with the NPK treatments. Nutrition generally caused an increase in the grain and straw alike, though in the former sometimes a decrease in concentration occurred.

Beryllium is one of those elements which have not much been studied and are unknown for their biological effect. In the experiment described here, its presence in the aboveground plant parts and in various phases of development could be detected with the method applied (Table 4). After the end of tillering the tendency of change indicated a decrease. In the straw the concentration increased, while in the grain the presence of beryllium could not be detected by the method used.

On most dates of sampling, fertilization was found to have caused significant concentration changes in the treatments. These changes were not systematic, since increases and decreases equally occurred. Increases were generally related to the nitrogen treatments, while in the nitrogen deficient treatments the concentration usually decreased compared to the control. A comparison of the phenophases shows that, at the time of shooting and in the stage of "milky ripening", the effects of fertilization differed from those observed in other phenophases, supposedly due to external factors.

Bismuth also belongs to those elements whose biological effect has not yet been determined (Bowen 1979), and it has mostly been studied from the environmental protection standpoint. In the *Triticale* plants examined, its concentrations measured did not even reach ppm quantities (Table 5). From the end of the tillering phase the change of concentration showed a decreasing tendency with minor fluctuations throughout the vegetation period.

Table 5

Effects of fertilization and vegetation period on the microelement content of Triticale
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
					Bi (ppm)						
1 0	0.69	0.78	0.56	0.27	0.46	0.34	0.42	0.43	0.38	0.11	0.73
2 N	0.65	0.90	0.56	0.28	0.48	0.40	0.40	0.48	0.20	0.11	0.66
3 P_1K_1	0.38	0.70	0.52	0.32	0.38	0.36	0.38	0.47	0.42	0.11	0.67
4 NP_1	0.67	0.98	0.66	0.50	0.61	0.51	0.46	0.48	0.43	0.11	0.71
5 NK_1	0.51	0.90	0.20	0.30	0.38	0.38	0.36	0.44	0.33	0.10	0.56
6 NP_1K_1	0.52	0.57	0.21	0.32	0.42	0.42	0.36	0.22	0.36	0.09	0.70
7 NP_2K_2	0.50	0.85	0.20	0.28	0.42	0.36	0.39	0.41	0.35	0.10	0.62
$LSD_{5\%}$	—	—	0.26	0.07	0.03	0.03	0.01	0.11	0.10	0.01	0.06
					Te (ppm)						
1 0	1.10	0.81	0.66	0.56	0.62	0.52	0.56	0.70	0.64	0.82	0.92
2 N	0.99	0.87	0.61	0.47	0.62	0.54	0.52	0.54	0.54	0.98	0.78
3 P_1K_1	0.91	0.81	0.59	0.56	0.54	0.59	0.52	0.47	0.56	0.78	0.82
4 NP_1	1.10	1.05	0.75	0.86	0.71	0.59	0.59	0.47	0.56	0.94	1.12
5 NK_1	1.03	0.96	0.51	0.52	0.64	0.50	0.45	0.68	0.50	0.85	0.87
6 NP_1K_1	1.21	1.02	0.65	1.05	0.89	0.61	0.59	0.57	0.52	0.89	1.29
7 NP_2K_2	1.33	1.05	0.63	0.68	0.82	0.66	0.66	0.59	0.56	0.94	1.22
$LSD_{5\%}$	—	—	0.18	0.26	0.15	0.12	0.13	0.11	0.16	0.10	0.16

Nutrition resulted in statistically demonstrable changes, except on two dates of sampling. Its effect was generally felt in an increase of concentration — except in the straw —, but negative changes also occurred. The effect of fertilization could not be proved consistent, nor could it be explained by the different nutrition treatments.

The effect of **tellurium** on plants has hardly been studied, and its biological importance is little known (Bowen 1979). Its concentration in the aboveground part of the *Triticale* plant could be measured at various times during vegetation (Table 5). The concentrations following a maximum at the time of tillering became lower and lower until the stage of "milky ripeness"; then, in full maturity, an increase in concentration was observed both in grain and in straw.

With the exception of a single sampling date NPK nutrition was found to cause significant changes. Its effect mostly manifested itself in an increase of concentration, though on some ocassions of sampling decreases also occurred. On the basis of the changes — though they were statistically reliable — the effect of fertilization did not prove consistent.

Table 6

Effects of fertilization and vegetation period on the microelement content of Triticale
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
					Sb (ppb)						
1 0	12.2	4.3	—	—	—	4.6	5.4	5.2	5.0	1.3	8.6
2 N	11.1	4.2	—	—	—	5.2	5.2	5.8	5.0	1.3	7.4
3 P_1K_1	8.6	3.8	—	—	—	5.1	5.2	5.4	5.6	1.3	8.0
4 NP_1	12.7	5.1	—	—	—	6.3	5.8	5.6	5.6	1.2	8.5
5 NK_1	10.3	4.5	—	—	—	5.0	4.9	6.0	5.2	1.2	6.6
6 NP_1K_1	10.8	4.1	—	—	—	5.7	5.1	5.1	5.2	1.3	8.5
7 NP_2K_2	10.1	4.1	—	—	—	5.1	5.1	5.2	5.1	1.3	7.6
$LSD_{5\%}$	2.4	—	—	—	—	0.3	0.1	0.5	0.4	0.06	0.4
					Sr (ppm)						
1 0	5.82	2.58	2.20	2.00	2.20	1.50	1.60	1.80	2.00	0.22	5.86
2 N	6.64	3.14	2.40	2.20	2.60	2.10	1.70	1.60	2.40	0.28	7.02
3 P_1K_1	5.91	3.25	2.20	2.40	2.70	2.00	1.80	1.90	2.20	0.24	6.70
4 NP_1	8.28	3.99	3.40	3.40	3.50	2.60	2.20	2.00	3.00	0.34	9.50
5 NP_1	6.26	3.12	2.20	2.40	2.40	2.00	1.80	3.10	2.80	0.24	6.17
6 NP_1K_1	8.47	4.05	2.80	2.50	2.80	2.20	1.80	1.40	1.90	0.26	8.58
7 NP_2K_2	9.42	4.24	3.10	3.00	3.20	2.50	2.00	1.90	2.40	0.28	8.10
$LSD_{5\%}$	1 .92	0.69	0.30	0.30	0.40	0.20	0.30	0.30	0.50	0.04	0.54

The role of **antimony** and its influence on plants have been little studied, so that its biological importance in plant life is not known (Bowen 1979). On some dates of sampling its concentration in the plants examined could not be determined with the method applied (Table 6). The maxima were measured at the time of tillering, after which its concentration decreased. The decrease, though minimum in the generative phase, resulted in rather low concentrations in the grain.

In the phenophases of tillering and milky ripening NPK nutrition caused a decrease, while in the generative phase usually an increase in concentration.

Strontium is another microelement which does not belong to the essential elements of vascular plants. Its biological importance is little, if at all, known. Nevertheless, it can be detected in plants and is relatively easily available in the soil. Its concentration in *Triticale* plants could be determined on all dates of sampling (Table 6).

From the phenophase of tillering to milky ripening its concentration — apart from a slight fluctuation — decreased. At the stage of maturity the value of concentration was particularly high in the straw, and low in the grain.

The effect of fertilization was statistically demonstrable on all dates of sampling. It appeared as an increase of concentration, first of all in the nitrogen treatments. Those treatments where potassium was used were generally characterized by a decrease of concentration similar to the dynamics of calcium (Wallace and Romney 1971).

Arsenic is not an essential element for vascular plants; its toxicity is a more important feature, from the standpoint of environmental protection as well (Chisholm 1972). In the aboveground part of *Triticale*, its presence was detected, except on a single date of sampling (Table 7). The maximum concentration appeared in an early phase of development (Feekes 4.), after which the concentration gradually decreased till the stage of milky ripening. Before full ripeness, the arsenic concentration increased both in the grain and in the straw.

From the time of earing the influence of fertilization could be statistically proved. Up to the time of flowering and in the straw this influence manifested itself in an increase, while in the generative phase and in the grain in a decrease of arsenic concentration. The effects were mostly linked to the nitrogen combinations.

The bioogical importance of **mercury** is unknown but more so its toxicity. It is rather widespread in nature (Juszkiewicz and Szprengier 1976). Its presence in the aboveground part of *Triticale* could be determined, though at very low concentrations (Table 7). The trend of concentration (Table 7) changinges during vegetation showed a steady decrease from the end of tillering to the time of harvesting, when the highest concentrations were found in the grain.

Fertilization resulted in significant changes — either increase or decrease

— in the concentration. However, no regularity in these effects could be established with any of the fertilizers used.

To decide the accuracy of measuring, variance analyses were made on each date of sampling for all elements. CV values calculated from the error variance of data are given in Table 8.

Table 7

Effects of fertilization and vegetation period on the microelement content of Triticale
(Total aboveground parts)

Treatment	Date of sampling										
	March	April			May		June			July 14	
	31	9	21	30	11	21	1	10	22	Grain	Straw
Feekes	2	4	6	7	8	9	10.1	10.5	11.1	11.4	
					As (ppb)						
1 0	41.6	84.8	—	8.9	22.0	18.0	19.0	21.0	19.0	37.5	32.5
2 N	51.0	105.9	—	33.4	30.0	13.0	17.0	20.0	13.0	40.5	28.4
3 P_1K_1	20.1	83.2	—	13.4	16.0	14.0	21.0	19.0	16.0	34.5	29.4
4 NP_1	32.1	104.4	—	25.6	28.0	17.0	18.0	18.0	17.0	33.5	34.5
5 NK_1	24.9	101.4	—	24.5	21.0	23.0	13.0	22.0	13.0	28.4	29.4
6 NP_1K_1	24.5	101.9	—	10.0	15.0	21.0	14.0	13.0	8.0	35.4	32.4
7 NP_2K_2	26.7	99.4	—	24.5	16.0	15.0	16.0	17.0	8.0	27.4	35.5
$LSD_{5\%}$	—	26.4	—	5.9	4.0	5.0	4.0	5.0	7.0	8.0	2.4
					Hg (ppb)						
1 0	12.0	24.4	18.0	8.0	10.0	8.0	8.0	10.0	5.0	2.9	1.2
2 N	9.2	29.9	18.0	12.0	11.0	8.0	8.0	10.0	2.0	3.0	1.0
3 P_1K_1	4.0	23.8	19.0	10.0	9.0	8.0	8.0	8.0	6.0	2.8	1.1
4 NP_1	6.7	30.2	19.0	11.0	10.0	10.0	10.0	7.0	6.0	2.9	1.1
5 NP_1	7.0	30.4	8.0	10.0	9.0	8.0	6.0	8.0	6.0	2.9	1.0
6 NP_1K_1	8.0	29.2	8.0	10.0	9.0	8.0	9.0	8.0	6.0	3.0	1.1
7 NP_2K_2	7.5	28.8	8.0	10.0	9.0	8.0	8.0	8.0	7.0	3.1	1.2
$LSD_{5\%}$	—	7.0	9.0	2.0	1.0	1.0	1.0	1.0	2.0	0.2	0.1

Table 8

Variation coefficients (CV%) at the dates and for the elements

Elements	March	April			May		June			July 14	
	31	2	21	30	11	21	2	10	22	Grain	Straw
B	34.2	39.9	35.6	29.3	41.5	58.7	17.7	48.8	16.5	19.6	16.3
Ba	16.0	24.7	27.0	18.0	17.5	13.8	12.5	15.8	15.1	9.6	5.6
Be	17.5	13.7	45.0	16.7	5.4	9.8	5.5	12.8	20.6	—	4.6
Bi	25.9	15.0	42.1	13.7	4.9	5.3	2.4	17.6	19.8	4.6	6.4
Sn	27.8	95.6	32.1	6.2	16.9	3.9	3.3	6.9	6.8	7.5	10.8
Sr	17.8	13.2	7.5	7.0	9.3	7.8	9.9	12.0	12.8	9.5	4.9
Sb	15.1	12.6	—	—	1.5	4.2	1.8	6.3	5.3	3.4	3.8
Te	20.8	17.4	19.6	26.4	14.7	14.7	15.6	12.9	19.1	7.5	4.7
Ti	—	21.9	—	29.1	81.1	—	—	—	—	—	21.8
Se	—	19.4	—	41.6	12.9	19.8	17.3	22.4	—	7.0	12.0
V	24.3	12.2	7.7	11.1	14.6	9.2	6.9	16.7	12.3	16.3	6.0
As	47.1	18.3	—	19.9	13.0	19.1	14.1	18.3	36.1	15.8	5.1
Hg	43.8	16.7	42.8	14.9	9.9	9.4	8.9	9.1	23.1	5.1	6.4

The data present a highly diversified picture, depending on the number and date of analyses and on the chemical element in question. For most elements examined, the average value of CV is between 10 and 20%. Average values higher than that were obtained for Ti and B, and a lower one for Sb.

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Acta Agronomica Hungarica 37 (3–4), pp. 257–263 (1988)

RESULTS OF ENERGY MEASUREMENTS ON VARIOUS MAJOR FIELD CROPS

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(Received 25 February 1986; accepted 8 January 1987)

One result of the increasing energy requirements of mankind, and of the problems involved in providing this energy, is the introduction of energy calculations and analyses into agricultural production. This paper deals with energy measurements and calculations carried out on the field crops winter wheat, maize, sugar beet and alfalfa, and summarizes the results which were included in sixteen papers recently published on this subject. The main findings are as follows: (1) When evaluating the energy aspects of plant production, comparisons should only be made between sets of input and output data which can be exactly measured using scientific methods. (2) During the period 1976–1980, in areas of Hungary with excellent fertility, using the most suitable variety and adequate fertilization, the energy value of the whole crop (main product, by-products, roots) produced on one hectare was 328.4 GJ for winter wheat, 343.1 GJ for maize, 296.9 GJ for sugar beet and 252.1 GJ for alfalfa, equivalent to 2.39%, 2.06%, 1.59% and 1.64%, respectively, of the photosynthetically active radiation *(PAR)*. The energy value of the elemental plant nutrients N, P and K incorporated into the yield, i.e. the quantity of energy which can be added to the above figures on the basis of the relative equivalent mass, is as follows (in MJ/kg): for winter wheat: N = 1121, P = 511, K = 128; for maize: N = 1317, P = 578, K = 174; for sugar beet: N = 693, P = 313, K = 83; and for alfalfa: N = 454, P = 205, K = 54.

Keywords: sugar beet, energetics, photosynthesis, maize, alfalfa, winter wheat, fertilization energetics

Introduction

The production of agricultural plant material is the joint result of a large number of technical, chemical and biological energy processes. This is why the use of energy parametrs has become standard practice when analysing production processes from the standpoint of economics. The calculations are carried out by comparing the input factors required for the crop production, expressed in uniform units (joules), with the value of the output, also expressed in joules. A thorough, very detailed evaluation of the input side was made by Kassay, Vida, Gyurján and Nagy (1980). The comparison is generally made by dividing the output value by the input value; the quotient obtained describes the efficiency of the system.

The size of the efficiency index depends on the number of factors and the type of data included in the input value and on what is taken as output value. In the case of field crop production, the input side of the energy producing efficiency of the individual crops (this is perhaps the best definition of

Table 1

Elemental N, P, K (kg/ha) applied to certain major field crops in Hungary during four five-year periods

Crop and year	N	P	K	N	P	K
	in total fertilizer			in artificial fertilizer		
Wheat						
1934—38	38.25	8.82	16.22	0.22	0.32	0.07
1956—60	51.90	11.61	21.28	9.39	1.93	3.00
1966—70	120.13	25.13	56.70	58.10	8.98	20.48
1976—80	212.78	45.26	131.07	123.75	23.40	85.24
Maize						
1934—38	43.44	11.12	26.43	0.25	0.38	0.12
1956—60	65.48	14.61	34.98	10.82	2.30	4.96
1966—70	154.63	31.15	84.96	66.96	10.67	33.82
1976—80	242.65	53.12	196.94	142.63	27.81	140.77
Sugar beet						
1934—38	133.94	39.49	155.90	0.26	0.31	0.18
1956—60	220.45	47.73	186.60	11.14	1.91	7.14
1966—70	355,74	84.52	289,75	68.93	8.85	48.66
1976—80	386.48	92.22	390.35	146.83	23.06	202.56
Alfalfa						
1934—38	37.23	9.01	17.83	0.06	0.15	0.05
1956—60	47.01	11.05	22.31	2.54	0.95	2.15
1966—70	90.29	21.26	53.27	15.75	4.42	14.65
1976—80	124.37	34.35	108.49	33.56	11.53	61.00

Table 2

Energy value (GJ/ha) used for production and contained in the yield of certain major field crops in Hungary

Crop and year	Mechanical work	Artificial fertilization	Total fertilization	Main product	Whole yield
Wheat					
1934—38	0.025	0.021	2.307	21.7	66.6
1956—60	0.413	0.552	3.114	23.7	67.8
1966—70	1.801	3.342	7.217	38.5	102.9
1976—80	2.304	7.578	13.050	64.3	157.6
Maize					
1934—38	0.027	0.025	2.716	30.3	116.8
1956—60	0.450	0.650	3.992	35.5	137.1
1966—70	1.711	3.944	9.341	49.6	145.3
1976—80	2.504	9.102	15.310	75.1	223.0
Sugar beet					
1934—38	0.042	0.023	9.124	67.5	82.3
1956—60	0.859	0.673	13.955	70.2	92.4
1966—70	3.180	4.111	23.644	104.5	145.2
1976—80	4.630	9.676	25.223	95.8	154.6
Alfalfa					
1934—38	0.024	0.007	2.274	60.2	111.8
1956—60	0.403	0.172	2.860	47.4	88.0
1966—70	1.475	1.036	5.578	60.7	112.8
1976—80	2.138	2.510	8.111	74.9	138.7

the index) is made up principally of the mechanical operations and the artificial fertilizer utilization, or in some cases the total fertilizer utilization. The output side usually consists of the energy value of the main product, but this may be replaced by the energy value of the whole yield (main product, by-products, roots).

Below, a review will be given of the energy producing efficiency of winter wheat, maize, sugar beet and alfalfa in Hungary during four five-year periods between 1934 and 1980 and of the results of calculations based on exact experimental measurements of the fertilization energetics of these crops.

Material and methods

The basic data discussed in this paper, the methodology applied in obtaining these data and the opinions and results on this subject reported in the literature are to be found in the publications listed below, so details need not be included here. The estimation of the mechanical work involved in crop production was made in terms of the so-called normal hectare work value: 1 normal hectare of mechanical work = 348.76 MJ (Debreczeni 1982). Detailed data on the mechanical work necessary for various field crops are presented by Debreczeni (1983a, 1983b, 1983c, 1985a).

The specific values of elemental N, P and K in fertilizers were taken as N = 50 242 J/g, P = 28 776 J/g and K = 8071 J/g, after Pimentel (1980). The fertilizer utilization data shown in Table 1 were compiled on the basis of Agricultural data base III (1980) and Debreczeni (1986). The total fertilizer given in the table includes the quantity of NPK introduced into the soil with artificial fertilizers, stable manure, liquid manure, root and stubble remnants, straw and maize stalks, and the nitrogen reaching the soil directly from the atmosphere.

The measurements required to determine the energy value of plant organs were carried out in the bomb calorimeter in the Institute of Ecology of Kossuth Lajos University, Debrecen (Debreczeni, Izsáki and Papp 1984). The basic data on the quantity of energy in the main product and the whole yield, summarized in Table 2, are taken from Debreczeni and Posza (1983), Debreczeni and Izsáki (1984), Izsáki and Debreczeni (1983, 1984) and Debreczeni (1984).

Results

The energy-producing efficiencies, i. e. the output: input ratios, of various field crops are presented in Table 3. It can be seen from the data that the efficiency values fluctuate considerably. Characteristically, the amount of energy invested increases to a greater extent than the energy removed with the yield. A similar conclusion can be drawn from an analysis of the works of Akócsi, Balogh and Nagy (1978) and Balogh (1978). A further reduction in the efficiency values would have occurred if plant protection chemicals and the energy used recently for drying and product treatment had been included on the input side.

In addition to the number of input and output factors, the efficiency is also influenced by the sources from which the specific values of the individual factors are taken and the spirit in which they were determined. Very often these figures include not only the results of scientific measurements, but also

Table 3

Output : input ratio in terms of production energy for various major field crops in Hungary during four years

Year	Wheat	Maize	Sugar beet	Alfalfa
"A" output : input = Main product : Mechanical work + Artificial fertilizer				
1934—38	602.17	582.69	1038.46	1940.94
1956—60	24.56	32.27	45.82	82.43
1966—70	7.49	8.77	14.33	24.17
1976—80	6.50	6.47	6.70	16.11
"B" output : input = Whole yield : Mechanical work + Total fertilizer				
1934—38	28.56	42.58	9.02	48.65
1956—60	20.84	30.86	6.62	26.97
1966—70	11.41	13.15	6.14	15.99
1976—80	10.26	12.52	6.13	13.52

objectified voluntary work, the value of which can only be estimated in some cases. The situation is very similar when the output of certain crops (the yield) is the result of exact scientific measurements, but certain items in the input (e.g. the intellectual work involved in the production of plant protection agents or machinery) include data which belong to the realm of social sciences.

In the case of economic analyses, if the period covered is short or free of inflation, and if the prevailing price relations are realistic, it is better to express the production costs in terms of money and to give the output, too, as the monetary value of the product. The efficiency is then calculated as the ratio of these values. Calculations in terms of energy units are best reserved for scientific analyses.

In crop production, research into the biochemical and biophysical processes of photosynthesis is one field where energy measurements are definitely required, since the mass of plant organic matter is formed due to the effect of light energy. The process can be described quite simply as follows: under the influence of the light quantum absorbed by the chlorophyll molecule from light energy, the $NADP^+$ present in the plant takes up electrons to form a reducing $NADPH^{2+}$—H^+ system and initiates the creation of organic matter. The process is described in detail, backed up by measurements, numerical data and specific production experience, in an earlier paper (Debreczeni 1985b).

Field crops utilize a very small proportion, 1–2%, of the photosynthetically active radiation *(PAR)*. Naturally, under optimum agronomic conditions this figure is somewhat higher and under less favourable conditions somewhat lower.

The results of energy measurements carried out in experiments on winter wheat, maize, sugar beet and alfalfa grown on soil with excellent fertility,

Table 4

Mean annual energy output of the whole yield for various major field crops under the effect of various fertilizer treatments (Kondoros 1976–1980)

No.	Fertilizer treatment, kg/ha*			Wheat 1979–1980		Maize 1976–1980		Sugar beet 1978–1980		Alfalfa 1978–1980	
	N	P	K	GJ/ha	PAR %	GJ/ha	PAR %	GJ/ha	PAR %	GJ/ha	PAR %
1.	20	7	13	252.3	1.86	300.9	1.80	252.5	1.35	197.8	1.27
2.	20	38	65	287,1	2.03	319.9	1.92	276.6	1.48	227.9	1.45
3.	120	38	65	345.4	2.58	340.5	2.04	301.0	1.61	253.4	1.65
4.	220	38	65	352.7	2.51	358.3	2.15	298.8	1.60	267.8	1.72
5.	420	38	65	346.3	2.57	354.3	2.12	302.4	1.62	213.8	1.59
6.	147	32	97	357.5	2.63	344.2	2.06	309.3	1.66	251.8	1.61
7.	266	43	162	333.4	2.48	362.3	2.17	320.3	1.72	292.7	1.87
8.	513	77	310	352.5	2.50	364.1	2.18	314.5	1.68	312.0	1.99
Mean	216	39	105	328.4	2.39	343.1	2.06	296.9	1.59	252.1	1.64

* 1. In the roots of the fore-crop; 2–5. In artifical fertilizer; 6–8. In liquid manure.

using the variety best suited to the region and identical fertilizer treatments, are summarized in Table 4. The detailed results can be found in papers published by Debreczeni and Posza (1983), Debreczeni (1985c, 1985d) and Izsáki and Debreczeni (1983, 1984).

It can be seen from the energy measurements that maize is able to fix the largest quantity of energy. This is followed by wheat, sugar beet and finally alfalfa. It should be noted, however, that in the case of alfalfa the low yield obtained in the first year, when the stand was established, substantially reduced the three-year average. The generally accepted order is quite different from this, probably due to a consideration of the food and feed value of the main products. Table 5 shows the numerical energy value of the main products, averaged over the experiment. In this case alfalfa takes first place because, apart from the roots remaining in the ground, the whole of the yield is main product. The energy value of topped beets puts sugar beet in second place, followed by maize and wheat.

Table 5

Quantity and ratio of energy in the whole yield and main product of various major field crops (Kondoros 1976–1980)

Crop	Whole yield, GJ/ha	Main product		
		Designation	GJ/ha	%
Wheat	328.4	Wheat grain	120.4	36.6
Maize	343.1	Grain maize	147.6	43.0
Sugar beet	296.9	Topped beets	171.0	57.6
Alfalfa	252.1	Lucerne	197.4	78.3

It would be expedient to determine as many scientifically based energy parameters as possible within the production process. Efforts were thus made to establish the energy values of elemental N, P and K, the major plant nutrients within the production process, in the case of wheat, maize, sugar beet and alfalfa. The course of the determination is described in detail by Debreczeni (1985c, 1985d, 1985e). Briefly, the method involves adding the energy of the whole yield, in terms of relative equivalent mass, to the elemental nitrogen, phosphorus and potassium contained in the yield. The results are presented in

Table 6

Energy value of 1 kg of elemental plant nutrients for various major field crops, MJ

Crop	N	P	K
Wheat	1121	511	128
Maize	1317	578	154
Sugar beet	693	313	83
Alfalfa	454	205	54

Table 6, averaged for each crop. It can be seen from the data that plant nutrients are best utilized by maize, closely followed by wheat. Very much poorer results were given by sugar beet and alfalfa. It was found in this experiment that the incorporation of 1 kg of the plant nutrient nitrogen led to the creation of organic matter with and energy value of 1300 MJ in maize and around 1100 MJ in wheat. Under the same agronomic conditions, this value was around 700 MJ for sugar beet and only 450 MJ for alfalfa.

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Acta Agronomica Hungarica 37 (3–4), pp. 265–268 (1988)

INFLUENCE OF TILLAGE PRACTICES IN PHYSICAL PROPERTIES AND WHEAT PRODUCTION

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(Received 14 November 1985; accepted 28 January 1987)

The aim of the present investigation was to study the changes brought about in physical soil environment by the use of various tillage practices and the response of wheat crop to the changed environment. The mould board produces the significantly largest clod *(MWD)*, lowest bulk density and greatest porosity. Among tillage treatments, mould board and disk proved superior in their yield performance. The increase in yield was ascribed to improved physical soil properties and root development.

Keywords: wheat, *Triticum aesetivum*, soil., tillage, yield

Introduction

Tillage modifies physical condition of the soil surface, but its requirement varies with the crops as well as with the prevailing soil climate condition. It is important to define the optimum tillage condition with respect to physical necessities of the crop and the root zone for a particular crop. Tillage operations that provide a conducive soil environment around the seeds and also provide an improved contact between seed and soil are generally considered to be good (Dasberg et al., (1962)). Unger and Stewart (1976) suggested that poor seed-soil contact has been a major problem in tillage crop food production. Tillage, which produces clods in the range of 3.2 to 6.4 mm aggregate, may produce higher sugarcane yield Jain and Agrawal (1970). Finer than 3.2 mm dia aggregate may produce higher bulk density and lower porosity which in turn affect aeration and increase soil strength. Root proliferation depends mostly on the soil's physical environment. Tillage directly affects the bulk density. A higher bulk density in the root zone may adversely affect root growth. Under such conditions the root development and proliferation are restricted, which restrict the feeding zone Flocker et al., (1960). Since tillage operations involve huge expenditures in farming, attempts were made to study more precisely the crop requirements and then provide the correct type of tillage practices.

Material and methods

The experiment was conducted on Kharagpur lateritic sandy loam soil. The soil has the following characteristics: sand 59%, silt 23% and clay 18%; Field capacity 14.5%, wilting point 4.5%, pH 5.4% and organic matter 0.4%. The soil is very low in nutrients and is underlain by laterite, composed of colloids of Fe and Al at about 70 cm depth. Just prior to the

Table 1

Treatment details of experiment

Treatment	Equipment	Description
T_1	Mould board	Ploughing with tractor drawn mould board *(MB)* plough followed by harrowing with a tractor drawn disc harrow;
T_2	Disk	Ploughing with tractor drawn disk plough followed by harrowing with tractor drawn disk;
T_3	Rotary tiller	Tilling of soil with rotary tiller;
T_4	Country plough	Ploughing with bullock-drawn country plough followed by bullock-drawn disk harrow;
T_5	Zero tillage	The plots were not ploughed.

seedling of wheat, the experimental plots were brought to a uniform condition as far as possible and various tillage implements were operated as described above (Table 1). The treatment consists of five tillage practices which were replicated thrice. A single pass was made in respect to implements in all the cases during the same day at the proctor soil moisture content of 9.8%. Wheat *(Triticum aestivum)* cultivar Kalyan Sona (S–227) was used as a test crop for the present experiment. This variety has two genes for dwarfing and hence has a very high degree of resistance to lodging. It is an intensive and high fertilizer-responsive variety with 100 to 110 days of duration. Observations in regard to fertile tiller number, number of grains per spike, and grain yield were taken from the plants of randomly selected 30 cm row length in the experimental plot. The grain yield of wheat was recorded after harvest and reported on kg/ha basis. The maximum depth of root penetration was measured by excavating soil with a 50 cm length and 15 cm diameter metal cylinder. The soil was washed from the bottom un.il the root tips were visible. The length of each soil core was measured and recorded as the length of root penetration. They were air dried to a constant weight at 85 °C. Soil samples were collected for the determination of clod *MWD*, bulk density and total porosity.

Results and discussion

Clod MWD

The clod *MWD* may be regarded as a measure of the structural state of seed bed that governs the physical soil properties. Table 2 reveals that significant differences in clod mean weight diameter *(MWD)* could be induced by

Table 2

Effect of tillage practices on clod mean weight diameter (MWD), bulk density and total porosity

Treatments	Clod MWD mm	Bulk density g cm^{-3}	Total porosity cm/10 cm
T_1	12.44	1.04	9.08
T_2	12.07	1.13	8.55
T_3	8.81	1.35	5.37
T_4	4.53	1.22	7.17
T_5	—	1.67	3.75
SEM ±	1.42	0.028	0.327
LSD $(P = 0.05\%)$	4.26	0.080	1.05
LSD $(P = 0.01\%)$	5.86	0.12	1.35

different tillage treatments. The clod *MWD* is maximum under mould board and minimum under rotary tiller. The higher clod *MWD* is attributed to the occurrence of larger clods, Bhadoria (1985). Bhusan and Ghildyal (1970) related the occurrence of higher clods under mould board with the radius of curvature of the plough.

Bulk density and porosity

Bulk density and total porosity, which are interrelated and very much modified by tillage tools, have direct bearing on the crop performance. The bulk density was found to be significantly lower in tilled plots and was related to the larger clod sizes, although there is no marked difference among tillage treatments. The decreased bulk density is associated with increased porosity which reflects an increase in the fraction of bulk volume not occupied with solids. Similar observations were made by Burwell et al (1963). There is a significant variation of porosity between the treatments. The soil under zero tillage had the maximum bulk density and hence the minimum porosity.

Grain yield

The data in Table 3 indicate that grain yield is significantly higher in tilled than untilled plots. Maximum yield is recorded under the mould board, followed closely by the disk. The country plough gives a significantly higher yield than the rotary tiller at 5% level. The latter, though inferior to other tillage treatments, has been found better for untilled plots. Similar patterns were also observed for yield attributes such as tiller number, grains per spike, etc. It also appears that poor root development and proliferation under smaller clods (T_4 and T_5) restrict the feeding zone, which ultimately affect the wheat grain yield. Reddy and Dakshina Murti (1971) also support these observations.

Table 3

Yield and yield attributes of wheat as influenced by tillage treatments

Treatment	Fertile tillers 30 cm drill (number)	Grain per-cent spike (number)	1000 grain weight, g	Grain yield, kg/ha
T_1	25.13	62.41	35.02	3496.6
T_2	24.22	60.33	34.64	3392.8
T_3	16.93	53.03	30.78	2249.1
T_4	18.92	54.17	32.18	2865.4
T_5	15.88	47.55	29.41	1938.0
SEM ±	1.28	1.25	0.484	193.1
LSD (P = 0.05%)	3.86	3.76	1.65	578.2
LSD (P = 0.01%)	5.16	5.01	1.92	771.1

Table 4

Root length and root weight of wheat as influenced by tillage practices

Treatment	Root length (cm)	Root weight (g)
T_1	35.33	26.24
T_2	36.83	26.18
T_3	24.26	21.39
T_4	22.15	15.16
T_5	21.53	11.01
SEM ±	1.55	1.39
LSD $_{(P = 0.05\%)}$	3.16	2.84
LSD $_{(P = 0.01\%)}$	4.26	3.82

The root length was significantly affected by tillage treatments. The mould board plough produced longest roots, and shortest roots were found in zero tilled plots. The variation in the root weight followed the same trend as that of root length (Table 4). The mould board opens up the subsurface soil and allows an easy infiltration of water, which also increases the root length and root weight. As a result, roots could exploit more moisture and soil nutrient from a greater soil depth, favourably influenced by adequate aeration, due to lower bulk density and higher porosity. A better root growth indirectly facilitated the growth of wheat and produced a higher grain yield. The above mentioned favourable physical soil environment was found to be created by a mould board and a disk in the seed bed. This has provided the adequate seed-soil contact to permit flow of water to roots, which is an index of the crop establishment. Khan (1980) also reported that the use of a mould board helped keep the bulk density low, and a greater moisture retention in the soil throughout the growth period of a groundnut crop.

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Acta Agronomica Hungarica 37 (3–4), pp. 269–275 (1988)

Plant genetics and breeding

SELECTION OF EARLY HEADING WHEATS IN THE PHYTOTRON

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(Received 13 May 1986; accepted 5 July 1986)

The experiments were intended to study the possibility of selecting for early heading in the phytotron. Plants from F_4 populations and from the parents were raised on an 11-hour day, after flower initiation, and the heading date was recorded. The possibility of selection was evaluated by means of progeny testing.

As a result of the phytotronic plant raising programme, heading was delayed. The difference in vegetation period between the varieties substantially increased.

The variation for the heading of hybrid populations was many times greater than that observed in the field.

Field progeny testing of individuals, which had differing heading dates in the phytotron, confirmed the possibility of selection in the phytotron for the combinations GK Tarján /NS 2699 and Olesen /K–1// Mv 5. A successful selection for heading date can be carried out in the phytotron if there is at least 3–4 days difference in the vegetation periods.

The combination Sz 3468/Mv 5 continued to segregate for heading date in the F_5 generation, so the selection of early plants from this population was ineffective.

Keywords: daylength response, earliness, wheat

Introduction

Early ripening in wheat is a favourable agronomic trait from several points of view. Early varieties avoid the danger of pathogens, drought, heat and other stress effects which occur in the second half of the vegetation period, particularly during the later stages, and cause considerable damage. In addition, early ripening has many advantages for farm management.

Genetically, the vegetation period is determined polyfactorially. The length of the development phases depends to a great extent on climatic factors, so it is difficult to determine the vegetation periods of the varieties in a single year (Balla 1967).

Climatic chambers and modern greenhouses are becoming more and more widespread, opening up possibilities for accelerated, more efficient breeding. To date, a wheat breeding method has been elaborated combining the phytotron, greenhouse and field facilities; and a technique has been developed for the simultaneous greenhouse selection of semi-dwarf and powdery mildew-resistant genotypes (Balla 1980a, 1980b, Bedő et al. 1980). It would be expedient to expand the greenhouse selection technique to include selection for earliness. This would necessitate a method by which those plants that head and ripen early, under field conditions, could be reliably selected under such conditions as greenhouse temperature, light, etc.

The most important environmental factors regulating the flowering date are daylength and temperature (Bonner and Galston 1952). According to Yasuda and Shimoyama (1965) the earliness of winter wheat depends almost entirely on the sensitivity of the plant to a short photoperiod, after vernalization. A study of 208 spring and winter wheats demonstrated a very close ($r = 0.873^{***}$) significant correlation between the photoperiod sensitivity and vegetation period.

The effect of short days on the vegetation period can still be demonstrated after flower initiation (Purvis 1934, McKinney and Sando 1935, Gott 1961, Rawson 1971, Balla 1982) and even during the flowering and ripening periods (Thorne et al. 1968).

The later development of the ear also proceeds most rapidly under long-day illumination (Riddell et al. 1958, Halse and Weir 1970), though the daylength requirement in this period may differ from the photoperiod needed for flower initiation (Riddell et al. 1958).

In experiments carried out by Purvis (1934) on rye and Halse and Weir (1970) on wheat, several varieties which had passed beyond the flower initiation stage neither headed nor flowered under short day conditions. The ears of these varieties became old and died in the leaf sheath.

The idea that breeding programmes should be devoted to accelerating flower development and exploiting the hereditary differences in the development rate, was raised a considerable time ago by Pinthus (1963).

Evans et al. (1975) warn of the possible hazards this would involve, since an accelerated, shorter flower development period could lead to a reduction in productivity in the number of spikelets, and possibly in the number of fertile flowers. The optimum rate of flower development ensures a satisfactory number of spikelets and flowers and an adequate grain filling. Depending on the local environmental conditions, this compromise will differ from one variety to another.

The possibility of selecting wheat types with rapid flower development and early heading was studied by Láng (1981, 1982). The results show that, in a controlled environment, when plants are raised on an 11-hour day after flower initiation, varieties with different vegetation periods can be readily distinguished. In order to confirm these results, a selection experiment was set up in the Martonvásár phytotron.

Material and methods

The experiments were carried out at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár, between 1981 and 1984. Three F_3 populations originating from crosses between early and medium early varieties were chosen for the experiments, together with the parent (Table 1).

Table 1

Combinations and varieties tested

Combinations	Varieties
Olesen/Krasnodari 1/Mv 5	Olesen Krasnodari 1 Martonvásári 5
Sz 3468-5-14-3-1-0/Mv 5	Sz 3468-5-14-3-1-0 Martonvásári 5
GK Tarján/NS 2699	GK Tarján NS 2699

The plants were raised in the phytotron between April 1st and November 1st 1981. The vernalization treatment was carried out using a method described in the literature and modified at Martonvásár. The wheat grains were germinated for 48 hours in Petri dishes at 18 °C, then planted in plastic tubes filled with soil and vernalized at +2 °C under weak blue illumination (1000 lux) for 50 days in vernalization chambers.

At the end of vernalization, the plants were transferred to pots and placed in two GB chambers. During the initial stages of development, until the 28th day after planting out, i.e. approximately until the beginning of shooting, the plants were raised at 14–16 °C with a day illumination of 13–15 hours, followed by 11-hour daylenght treatment until heading, The heading date was recorded separately for each plant. After the completion of heading, the plants were ripened at 20–22 °C with a 15-hour daylength and harvested individually.

In 1982/1983 the yield of 15–22 plants per populations with differing heading dates were sown in the field for progeny testing. The parent varieties used in the combinations were also sown. The experiments were set up under optimum field conditions in the Martonvásár wheat nursery. The rows were spaced 15 cm, the plants 5 cm apart, surrounded by border strips.

The heading date was determined for each individual plant and recorded as the number of days from January 1st.

The correlation between heading date in the phytotron and the field was determined for each population by means of correlation analysis.

In 1983/1984 progeny testing was repeated in head rows and the heading date was determined.

Results

Under the plant raising conditions applied in the phytotron, the heading dynamics of the varieties and populations differed considerably from that observed in the field. While in thin stands in the field, the main ears of individual wheat varieties headed within 3–8 days, depending on the temperature, uniformity, etc.; slow, delayed heading was observed in the phytotron experiment. The heading of each variety took 7–18 days.

Under the effect of daylength treatment, not only did the heading period of the varieties become substantially longer, but the deviation in the mean value of the varieties also greatly increased. The varieties Krasnodari 1 and Martonvásári 5, which generally head on the same day in the field, also had similar vegetation periods in the phytotron. At Martonvásár, the lines GK

Table 2

Heading date in the phytotron (number of days from planting out) Martonvásár, 1981/1982

Variety, population	n	$\bar{x}$	s	CV%	Interval	Variation range
GK Tarján/NS 2699	114	60	5.24	8.69	51–77	27
GK Tarján	20	53	1.97	3.70	50–56	7
NS 2699	18	70	3.34	4.80	65–77	13
Olesen/K–1F_6//Mv 5	268	61	7.18	11.76	52–77	26
Olesen	17	52	3.76	7.26	48–59	12
Krasnodari 1	15	67	4.32	6.44	60–77	18
Martonvásári 5	19	65	3.34	5.10	59–75	17
Sz 3468-5-14-3-1-0/Mv 5	129	64	4.4	6.93	55–75	21
Sz 3468-5-14-3-1-0	20	60	3.66	6.16	54–66	13
Martonvásári 5	15	72	3.52	4.92	67–77	11

Table 3

Heading date in the field Martonvásár, 1982/1983

Variety, population	n	$\bar{x}$	s	CV%	Interval	Variation range
GK Tarján/NS 2699	80	135	2.50	1.85	129–142	14
GK Tarján	11	131	1.01	0.77	129–132	4
NS 2699	25	138	1.51	1.09	135–142	8
Olesen/K–1F//Mv 5	205	137	9.82	7.16	133–141	9
Olesen	32	133	1.06	0.80	131–134	4
Krasnodari 1	34	138	1.43	1.03	136–141	6
Martonvásári 5	44	139	1.14	0.82	137–142	6
Sz 3468/Mv 5	98	135	13.89	10.28	133–142	10
Sz 3468	3	133	1.00	0.75	132–134	3
Martonvásári 5	29	139	1.18	0.85	137–141	5

Tarján and NS 2699 head 5–6 days apart on average under field conditions; whereas, under the plant raising conditions applied in the phytotron, this difference increased to more than 16 days. There was a similar increase in the differences between the vegetation periods of Sz 3468 and Martonvásári 5, and between those of Olesen and Martonvásári 5 (Tables 2 and 3).

The plants of the hybrid populations, that were tested headed over an interval of 21–27 days (Table 2), which is many times greater than the period observed in the field. The heading dynamics showed normal distribution in all three populations.

On the heading of individual plants it is characteristically found that, irrespective of the genotype, a few poorly developed plants head late, which slightly distorts the downward branch of the normal distribution curve. This can also be observed in the case of phytotronic raising.

The heading dates of the populations were intermediate; neither positive nor negative transgression was observed.

The deviation and variance coefficients of heading date in the populations tested were significantly greater than those of the parent varieties in the case of the combinations GK Tarján /NS 2699 and Olesen/K–1//Mv 5, and moderately so for the combination Sz 3468/Mv 5.

The prolongation of heading under short-day plant raising conditions in the phytotron would appear to facilitate the separation of genotypes with different vegetation periods, producing differences in heading which are only found in the field in years with extreme weather conditions. It follows, from the wide intervals of heading time obtained in the phytotron, that there will only be a deviation in the heading time of varieties or individuals in the field if there was a difference of several days in the phytotron. Progeny tests were used to check whether the differences in heading date were due to experimental error or to the magnification of real differences in the vegetation period between the genotypes.

Field tests on the progeny of plants heading at different times in the phytotron showed the following results (Table 3): In 1983 under field conditions the heading dates of the varieties were characteristic of the varieties; there was a difference of 5–7 days between the heading of early and late parent varieties. Within the varieties, the range for heading varied between 3 and 8 days. The deviation values were smaller than in the phytotron, although varieties which headed over a longer period in the phytotron also headed longer in the field.

The mean values of heading time for the populations, as in the phytotron experiment, also fell between the mean values of the parents in the field. None of the populations produced individuals earlier than the early parent and only one plant in the Sz 3468/Mv 5 combination headed later than the late parent.

The range for the heading date of the populations tested was 9–14 days under field conditions, approximately half of the value observed in the phytotron.

When comparing heading dates in the phytotron and under field conditions, the following results were obtained (Table 4).

The heading date of F_4 populations of GK Tarján /NS 2699 and Olesen/ /K–1//Mv 5/, observed under phytotronic plant raising conditions, was also significantly reproducible under field conditions. Individuals which headed early in the phytotron were also early in the field; this indicates that, for these

Table 4

Correlation between heading dates in the phytotron and in the field Martonvásár, 1982/1983

Combination	r	a	b
GK Tarján/NS 2699	0.773***	120.5	0.25
Population + parents	0.752***	115.1	0.32
Olesen/K–1//Mv 5	0.845***	121.3	0.26
Population + parents	0.839***	121.3	0.26
Sz 3468/Mv 5	0.329	131.3	0.08
Population + parents	0.465	124.9	0.17
	0.63***	119.3	0.27

two populations, successful selection can be carried out using the climatic programme employed in the experiment. It can be seen from the value of the regression coefficient that there must be a difference in heading date of some four days in the phytotron if there is to be a perceptible difference in vegetation period in the field.

In the case of the Sz 3468/Mv 5 population, no correlation was found between heading date in the phytotron and under field conditions, despite the fact that the heading dates of the parent plants showed a close correlation ($r = 0.970^*$ and $r = 0.999^*$) in the two experiments. The reason for the lack of correlation may be that the population is still segregating for vegetation period. This is confirmed by the repeated progeny test (Table 5). The vegetation

Table 5

Correlation between heading dates in 1983 and 1984

Combination	r	a	b
GK Tarján/NS 2699	0.838***	34.5	0.84
Population + parents	0.870***	35.4	0.83
Olesen/K–1//Mv 5	0.565*	100.9	0.36
Population + parents	0.561**	99.9	0.37
Sz 3468/Mv 5	0.431	69.1	0.58
Population + parents	0.805***	—29.6	1.31
	0.839***	20.5	0.95

period of F_5 ear progeny lines originating from ears selected in the F_4 generation shows the weakest correlation with the data of the previous year ($r = 0.431$) in this combination. Since the parent varieties did not segregate for heading date, the joint correlation of the population and the parents is close and significant ($r = 0.805^{***}$).

Further segregation for heading date can also be observed in the Olesen/ /K–1//Mv 5 population.

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Acta Agronomica Hungarica 37 (3—4), pp. 277—286 (1988)

GENETIC ANALYSIS FOR SEEDLING VIGOR, FORAGE AND SEED YIELD IN LEO BIRDSFOOT TREFOIL (*LOTUS CORNICULATUS* L.)

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(Received 16 September 1985; accepted 20 December 1985)

From a population of Leo Birdsfoot trefoil in the fourth cycle of a recurrent selection programme, and from an unselected population of certified Leo, genotypes were obtained and evaluated for seedling vigor, forage and seed yield. An autotetraploid inheritance model was then used to determine the genetic variability present in both populations.

The mean performances for all three traits in the selected population was higher than those of the unselected population. Estimates of broadsense heritability were low to moderate for the traits. However, zero narrowsense heritability was obtained for seedling vigor in the selected population, while estimates of narrowsense heritability were higher than broadsense for seed yield in both populations. Additive genetic variance estimates were positive in both populations, but dominance variance estimates were negative. Implications for autotetraploid breeding and production of synthetics were discussed. Parent-offspring correlations were low to moderate, while trait correlations were generally positive.

Keywords: birdsfoot trefoil, autotetraploid, heritability, additive and dominance variance, seedling vigor, forage and seed yield

Introduction

Because of its perennial growth habit, tolerance to poor drainage and absence of bloat when grazed by livestock, birdsfoot trefoil has become an important forage legume in the United States and eastern Canada. Improvements on the Leo cultivar have been for better seedling vigor, forage and seed yield (Twamley, 1971; Sandha and Twamley, 1973; and Conje and Carlson, 1973). Studies on genetic variability of trefoil have been few and far between (Albrechtsen et al., 1966; Twamley, 1972; Sandha et al., 1977; Tomes et al., 1983). The estimate of narrow sense heritability for seedling vigor has been found to be as low as 0.12% (Twamley, 1972; Onokpise, 1980); thereby suggesting that genetic variability present among various birdsfoot trefoil populations for seedling vigor, is due to dominance or epistatic interactions.

Sandha et al., (1977), obtained moderate estimates of broad sense heritability for seed yield, plant height, forage grading and seeds per pod for

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polycross progenies and parents of selected plants of the cultivar Leo. Their estimates of dominance variance were negative, while estimates of additive variance were positive and high. Tomes et al., (1983), found that estimates of additive variance and broadsense heritabilities were similar in selected and unselected populations of Leo Birdsfoot trefoil for forage yield. Although, estimates of additive variance were significant in both populations, only the diverse unselected population showed significant estimates of dominance variance. This paper reports on the genetic analysis of an unselected population of certified Leo and a selected population from the fourth cycle of a recurrent selection programme of Leo Birdsfoot trefoil.

Material and methods

Polycross progenies for the genetic analysis of Leo Birdsfoot trefoil were produced ni the growth rooms of the Crop Science Dept. at the University of Guelph. Growth rooms were maintained at 22/20 °C and 16hr/8hr day (light intensity; 200 microeinsteins) and night conditions respectively (Onokpise, 1980; Onokpise et al., 1985). The progenies were obtained from an unselected population of the cultivar Leo and a selected population of the same cultivar in the 4th cycle of a within-half-sib recurrent selection programme (Tomes et al., 1983). Seedling vigor for parents and progenies was determined in the growth rooms, while forage and seed yield were evaluated at the Flora Experiment Station of the University of Guelph as reported elsewhere (Onokpise et al., 1985). Briefly, seedling vigor was obtained by measuring top growth 6 weeks after planting, while forage yield was determined by harvesting plants, three months after field planting. The plants in each plot were bulked as to their progeny and parental types, and dried in a high temperature dryer at 80 °C for 48 hours and dry weights were then taken on a plot basis. The dried plants were then threshed for seed yield determination, which was achieved by weighing seeds of progeny and parental plants separately.

Genetic analysis

The data for genetic studies were analyzed on a mean plot basis using a randomized complete block analysis of variance and covariance to improve the efficiency of genetic analysis. The replication and genotypic effects were assumed to be random. Genotypic and phenotypic variances for parental genotypes and polycross progenies were calculated from expected mean squares while parent offspring covariances were obtained from their expected mean cross products (Scossiroli et al., 1963).

Assuming autotetraploid inheritance for birdsfoot trefoil (Dawson, 1941; Bubar and Miri, 1965), the genotypic variance for polycross progenies (half-sibs) is equal to $1/4\,\sigma^2_A + 1/36\,\sigma^2_D$ (Kempthorne, 1969). These would provide for estimates of additive and dominance variance when the follwing equaoations er solved:

$$1/4\,\sigma^2_A + 1/36\,\sigma^2_D = \sigma^2_{HS} \tag{1}$$

$$1/2\,\sigma^2_A + 1/6^2_D = \sigma^2_{PO} \tag{2}$$

where σ^2_{HS} is covariance among half-sibs and σ^2_{PO} is parent-offspring covariance. The simultaneous equations reduce to the following:

$$\sigma^2_A = 6\sigma^2_{HS} - \sigma^2_{PO} \tag{3}$$

$$\sigma^2_D = 9\sigma^2_{PO} - 18\sigma^2_{HS} \tag{4}$$

The standard error for σ^2_D and σ_A^2 was obtained by taking the square root of the following equations:

$$\mathrm{Var}(\sigma^2_D) = (9\sigma^2_{PO} - 18\sigma^2_{HS})^2 = 81\mathrm{V}(\sigma^2_{PO}) + 324\mathrm{V}(\sigma^2_{HS}) - 324\ \mathrm{Cov}(\sigma^2_{PO}, \sigma^2_{HS}) \quad (5)$$

$$\text{Similarly, } \mathrm{Var}(\sigma^2_A) = 36\mathrm{V}(\sigma^2_{HS}) + \mathrm{V}(\sigma^2_{PO}) - 12\ \mathrm{Cov}(\sigma^2_{PO}, \sigma^2_{HS}) \quad (6)$$

Broad sense heritabilities (Falconer, 1981) were estimated for parental genotypes and polycross progenies using genotypic and phenotypic variances. Narrow sense heritabilities were determined by taking parent-offspring regressions with polycross progenies as half-sibs. This approach is considered the best for estimating narrow sense heritabilities among autotetraploids (Swanson et al., 1974). The formula for the parent-offspring regression (Kempthorne, 1969) is given by

$$b_{PO} \frac{1/2\ \sigma^2_A + 1/6\ \sigma^2_D}{\sigma^2_P} \quad (7)$$

where $1/2\ \sigma_A^2 + 1/6\ \sigma^2_D$ is the covariance of parents and offspring and σ^2_P is the variance among parents.

Additional assumptions necessary for the calculations included: no epistasis, random choice of parents for the production of experimental progenies, no genotype × environment interaction effects, chromosome type segregation, linkage equilibrium, random cross pollination in the production of half-sibs, no maternal effects.

Genotypes and phenotypic conponents of variance were used to calculate genotypic and phenotypic correlations between parents and progenies, and among the three traits (seedling vigor, forage and seed yield) within parents and within progenies.

Results and discussion

The mean performance among parental genotypes and polycross progenies, for all three traits evaluated, was higher in the selected population than the unselected population (Table 1). This would indicate that recurrent selection has been effective in improving these traits. Analyis of variance showed significant differences among polycross progenies for all three traits in the selected population, but for only forage yield in the unselected population (Table 2). Among parental genotypes, significant effects were found for seedling vigor and seed yield in the selected population, and for forage and seed yield in the unselected population. These significant meansquares suggested the presence of sufficient variability in both populations for further selection.

Table 1

Means (in grams/genotype) and standard errors for seedling vigor (SV), forage yield (FY), and seed yield (SY) in the selected and unselected populations of Leo Birdsfoot Trefoil

Source	Selected populations		Unselected populations	
	Parents	Polycross progenies	Parents	Polycross progenies
SV	0.71±0.25a	1.51±0.58b	—	1 .24±0.44c
FY	140±51d	309±60e	46±21f	302±65g
SY	6.26±2.73h	20.90±6.30i	0.49±0.37j	17.28±1.14k

Means within the same row followed by different letters are significantly different at 5% student T-test.

Mean cross products (Table 2) were significant for forage and seed yield in the selected population while only seed yield had significant levels for the unselected population. This would indicate that more significant differences between the progenies and parents as would be expected.

Table 2

Mean squares and mean cross products for separate analysis of variance and covariance for parental genotypes and polycross progenies, for SV, FY and SY in the two populations

Source	Mean squares				Mean cross products	
	Selected[1]		Unselected		Selected	Unselected
	Parents	Polycross progenies	Parents	Polycross progenies	Parents VS Polycross progenies	Parents VS Polycross progenies
SV	0.36**	1.17**	—	1.69	0.014	—
FY	2990.29	76537.91*	1424.98*	12259.23*	698.95**	86.52
SY	18.70*	112.88*	0.63*	37.86	34.90**	0.95*

[1] Degrees of freedom: Selected population = 20; unselected population = 6.
*** Significant at 0.05 and 0.01 probability levels.

Heritability estimates

The estimates of broadsense heritabilities in both populations were low to moderate for all three traits (Table 3). Except for forage yield, broadsense heritability *(Hbs)* was higher in the selected population than the unselected population. This would indicate that more genetic variability is present in the selected population than the unselected one. Sandha (1973) obtained higher estimates of broadsense heritability for seed yield and forage grading among parents and polycross progenies of the cultivar Leo in a population that was in the second cycle of a recurrent selection, similar to the population from which

Table 3

Broadsense and narrowsense heritability estimates for seedling vigor (SV), forage (FY) and seed yield (SY) in the selected and unselected populations

Source	Broadsense heritability (%)				Narrowsense heritability (%)	
	Selected		Unselected		Selected	Unselected
	Parents	Polycross progenies	Parents	Polycross progenies		
SV	52.9	38.18	—	0.50	0 ± 1.0	—
FY	7.71	21.36	35.94	31.87	7.85 ± 1.0	0.12 ± 25.0
SY	27.49	31.55	15.90	12.90	91.35 ± 13	73.0 ± 96.0

materials were obtained for the present studies. Twamley (1972), and Bresciani (1971) however obtained heritabilities similar to those reported here. The estimates of broadsense heritability presented in this paper are indications of sufficient genetic variability available in both populations for further selection. Whether this variability is due to additive or nonadditive effects is discussed later.

The narrowsense heritability (*Hns*) estimates in the selected population for forage yield were the same as *Hbs* (Table 3), thereby suggesting that all the genetic variability for this trait in the selected population is additive. The magnitude of *Hns* for forage yield would suggest that there should be further progeny testing for the improvement of this trait (Hill and Haag, 1974). The highest estimates of Hns were obtained for seed yield in which Hbs was less than *Hns* in both populations. Theoretically, *Hns* should be less than *Hbs*. Difficulties in obtaining reliable estimates of *Hns* have been discussed by Hanson (1963). Parent-offspring regression can sometimes result in very high estimates of *Hns*, due to a contraction of the phenotypic scale, especially if the trait is influenced by strong genotype × environment effects. Polycross progenies used for estimating *Hns* were produced from 42 and 11 genotypes of the selected and unselected population respectively (Onokpise, 1980; Onokpise et al., 1985). It is therefore anticipated that the numerator would have a higher value than the denominator made up of phenotypic variance obtained from 21 and 7 genotypes within each population. This contraction in the phenotypic scale may have resulted in the very high estimates of *Hns* for seed yield in both populations.

Although the *Hbs* for seedling vigor in the selected population suggested the availability of sufficient genetic variability for further selection, the *Hns* was zero, which would indicate that the variability present for seedling vigor after four cycles of selection may be essentially non-additive. Twamley (1972) also obtained a parent-offspring regression of 0.12 for seedling vigor in the cultivar Leo. While the method used for deriving the *Hns* was not given, he speculated that genetic variability for seedling vigor in the base population may be due to dominant/epistatic gene action.

Estimates of additive and dominance variance

The estimates of dominance variance (σ_D^2) were negative for all three traits while the estimates of additive variance (σ_A^2) were positive (Table 4). Dominance variance estimates, though negative, were higher in the selected population than the unselected population for forage yield but lower for seed yield. The estimates of σ_A^2 on the other hand were higher in the unselected population than the selected population for forage yield.

Table 4

Estimates of additive and dominance genetic variance in the selected and unselected populations for SV, FY and seed yield

Source	Additive variance (σA^2)		Dominance variance (σD^2)	
	Selected	Unselected	Selected	Unselected
SV	1.24 ± 2.73	—	-3.73 ± 8.18	—
FY	575.71 ± 40.76	1198.25 ± 12.43	-1605.78 ± 80.70	-3594.29 ± 37.31
SY	100.42 ± 74.15	21.26 ± 10.33	-245.08 ± 220.93	-62.81 ± 31.19

Negative estimates of dominance variance should be regarded as zero (Robinson et al., 1955, Christie, personal communication). This would suggest the absence of dominance variance in both populations for seedling vigor forage and seed yield. However, the broad sense heritability estimates indicated the presence of nonadditive genetic effects for these traits in both populations. Therefore, some of the assumptions made in the derivation of σ^2_D and σ^2_A may not hold true. Among these assumptions were: no epistasis, random cross fertilization in the production of progenies, no genetic maternal effects and random selection of parents.

The presence of epistatic interactions can cause disturbances in the derivation of σ^2_D. Although Twamley (1974) found no maternal effects for seedling vigor and seed size in Morshank trefoil, studies in other forage crops tend to indicate the presence of singificant maternal effects (Gutek et al., 1976). Maternal effects can lead to higher estimates of genetic components of variance and hence bias the estimates of σ^2_D. Furthermore, the problem of limited population size, especially in the unselected population (11 clones), could result in the lack of random parental selection. One factor that may influence the derivation of σ^2_D is non-random cross-fertilization in the production of polycross progenies. The non-random cross fertilization in forages has been reviewed (Gorz and Haskins, 1971) and there is some evidence of preferential crossing among trefoil plants (Schaaf and Hill, 1979). Such assortative mating would result in an upward bias for σ^2_D and a downward bias for σ^2_D. The magnitude of such bias could be such as to result in negative estimates of σ^2_D (Lindsay et al., 1962). Negative estimates of σ^2_D for seed yield and forage grading have also been reported for Leo birdsfoot trefoil (Sandha et al., 1977).

The positive estimates o σ^2_A may include interactions of the additive $\times$ $\times$ additive variance. The σ^2_A for fseedling vigor lends support to this idea. The narrow sense heritability for this trait in the selected population was zero, suggesting the absence of additive genetic variance in that population. Falconer (1981) indicated that estimates of σ^2_A made from parent-offspring covariance included $\sigma^2_{AA} + \sigma^2_{AAA} \ldots$, etc. This situation will be greater for autotetraploids

(Levings and Dudley, 1969), where digenic, trigenic and tetragenic interactions are known to be very strong (Carnahan, 1960; Demarly, 1963; Gallais, 1968; Dessureaux and Gallais, 1969). Although the present studies did not provide direct estimates for epistatic genetic effects, it is however postulated that σ^2_A obtained here, not only includes $\sigma^2_{AA} + \sigma^2_{AAA} + \sigma^2_{AAAA} \ldots$, etc., but also the additive × digenic, additive × trigenic, additive × tetragenic, ... etc., epistatic interactions ($\sigma^2_{AD} + \sigma^2_{AT} + \sigma^2_{AF} \ldots$, etc.).

This will result in very high estimates of σ^2_A and a subsequent increase in the estimate of broad sense heritability.

Theoretically, repeated selection should result in an accumulation of favorable genes (quality genes) and better gene combinations through crossing over and recombination (Webel and Lonquist, 1967). Whether such selection increases or decreases the average gene effects in the population, or increases favorable gene interactions, is a subject that has received limited attention (Rotili, 1976). Nei (1963), proposed that during selection in diploids the average gene effects declined rapidly after each cycle of selection. This decline was followed by σ^2_{AA}, and the least affected were σ^2_{AD} and σ^2_{DD}. This would suggest that, for an autotetraploid, many epistatic interactions will still remain after several cycles of selection. The maximum heterozygosity has been suggested for better performance in autotetraploids (Dunbier and Bingham, 1975). This may involve favorable genotypic structures and favorable gene combinations for a given trait or traits. If selection results in these gene combinations and structures, then there would be greater changes of epistatic interactions, which will lead to a low heritability for combining ability among plant genotypes thus selected. Therefore, if heritability is low in Syn 0, the Syn 1 generation combining ability will be low and Syn 2 may even be lower; hence lower forage and seed yield. Such decline is what is generally experienced in forage breeding (Twamley, 1972). Too large a proportion of epistatic gene action with its low heritability can also result in low yields. It is therefore important that, before any of the genotypes from the selected population used in the present study are put into a synthetic, they are tested for several generations so that only superior genotypes are composited into synthetics, if yields are not to decline in future generations of the synthetics.

Correlations

The genotypic and phenotypic correlations between progenies and parents in the selected population were zero for seedling vigor; and except for seed yield in the selected population, both types of correlations were low to moderate for forage yield in the two populations (Table 5) and seed yield in the unselected population. The low parent-offspring correlations are a reflection of the low

Table 5

Parent-offspring correlations for seedling, vigor, forage and seed yield in the two populations

Source	Genotypic correlations (r_G)		Phenotypic correlations (r_P)	
	Selected	Unselected	Selected	Unselected
Seedling Vigor	0	—	0.02	—
Forage Yield	0.47	0.001	0.15	0.02
Seed Yield	1.30*	0.23*	0.76	0.20

* Significant at $P < 0.05$.

heritability estimates and the presence of non-additive genetic effects, while the zero correlations for seedling vigor in the selected population also reflects the zero narrowsense heritability for this trait as earlier discussed.

Among parental genotypes in the selected population, seedling vigor was negatively correlated with forage yield (Table 6) and forage yield was positively

Table 6

Genotypic (r_G) and phenotypic (r_P) correlations among the three traits in the selected and unselected populations

Source	Selected population				Unselected population			
	Forage	Yield	Seed	Yield	Forage	Yield	Seed	Yield
	r_G	r_P	r_G	r_P	r_G	r_P	r_G	r_P
Seedling Vigor								
Parents	—0.73*	—0.33	0.01	0.07	—	—	—	—
Progenies	1.05*	0.62*	0.30	—0.19	0.57	0.30	0.83	0.61
Forage Yield								
Parents			0.40	0.35			1.12*	0.89*
Progenies			0.70	0.19			1.17*	0.89*

* Significant at $P < 0.05$.

correlated with seed yield. For polycross progenies, positive genotypic correlations were obtained between seedling vigor and the other traits which were also positively correlated in both populations. These results agree with those of Miller, 1969; Sandha et al., 1977. These positive genotypic correlations among all three traits within the polycross progenies is due more to the fact that, during the four cycles of selection, all three traits were emphasized for improvements. Therefore, further improvements in any one of the traits should not adversely affect the other traits, since favourable gene combinations for the traits may have been built into the population.

Acknowledgements

The financial assistance of the Ontario Ministry of Agriculture and Food for this project and the government of Nigeria for O.U. Onokpise are gratefully acknowledged. The authors are also grateful to Dr. B. R. Christie, Dept. of Crop Science, University of Guelph, Guelph Ontario, Canada, for advice on Statistical Genetics and his very valuable comments on the entire work. The technical assistance of Ms. Gail Bartlett is acknowledged with thanks.

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Acta Agronomica Hungarica 37 (3—4), pp. 287—292 (1988)

RELATIONSHIP BETWEEN SEED YIELD, OIL CONTENT AND THEIR COMPONENTS IN SESAME (*SESAMUM INDICUM* L.)

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(Received: 10 April 1986; accepted 15 December 1986)

Eleven male — sterile X male — fertile sesame (*Sesamum indicum* L.) hybrids, and their parents were evaluated for one season at the USDA Cotton Research Station in Shafter, California. Oil content and yield per acre (as dependent variables) and seven of their components were determined and used to compute partial and multiple regressions as well as multiple correlation coefficients in both the F_1's and their parents.

Number of capsules per plant and plant height accounted for 87.2** (in the F_1's) and 95.0**% (in the parents) of the variability in yield. Partial regression analysis indicated that, when average heights of 253 cm in the F_1's and 217 cm in the parents were maintained, number of capsules per plant was the most important character — followed by number and weight of seeds per capsule — to be considered in selecting high yielding strains.

With few exceptions, all of the regression and correlation coefficients computed for oil content were either low or insignificant, indicating the difficulties encountered in selecting for this trait.

Keywords: sesam, *Sesamum indicum* L., seed yield, oil content

Introduction

Knowledge of inter-relationships among morphological characters and yield is invaluable to the breeder in selecting desirable strains. The present study deals with partial, multiple regression and correlation analysis between seed yield/oil content (as independent variable) and seven of their components in 11 sesame hybrids and their parents.

Sikka and Gupta (1949), Osman and Khidir (1974) worked out simple, partial and multiple correlations and regression between plant height, number of branches per plant, number of capsules per plant and seed yield in sesame, reporting that the greatest contribution to yield was made by number of capsules per plant followed by plant height and for number of branches per plant. Phadnis et al. (1969–70) worked out contributions of various plant characters to total yield in eight cultivars of sesame and observed that the highest contribution (43.2–89.0%) was made by number of capsules per plant.

To the best of my knowledge, no work was conducted to evaluate the contribution of various plant characters in the variability associated with oil content in sesame.

Material and methods

Eleven inbred sesame lines selected from the University of California sesame breeding nursery at Riverside were crossed to a male-sterile stock, isolated from a tropical material obtained from D. B. Mazzani, Centro de Investigationes Agropecuarias, Maracay, Venezuela. Eleven F_1 hybrids were obtained. The 11 F_1 hybrids and their 11 parents were planted in the Summer of 1979 at the USDA Cotton Research Station in Shafter, California. Detailed description of the materials and methods for the trail were given in a previous paper (Osman 1986). Regression and correlation analyses were computed as suggested by Snedocor and Cochron (1967).

Results and discussion

Plant characteristics

Table 1 presents the mean and the standard error of the 9 characteis of the 11 sesame hybrids and their parents. A t-test indicated that, on the average, the F_1's were significantly taller ($P = 0.01$) and had a higher yield than their fertile parents.

Table 1

Variability in 9 treits in 11 sesame hybrids and their parents

Character and code*	F_1's		Parents	
	Range	Mean $\pm$ S.E.	Range	Mean $\pm$ S.E.
(1) Plant height (cm)	209—277	253 ± 13.0	179—271	217 ± 10.9
(2) Height to I and capsule (cm)	78—171	132 ± 98.3	61—209	127 ± 9.4
(3) No. of capsules/plant	36—84	60 ± 8.8	22—97	54 ± 6.5
(4) Capsule length (mm)	25.3—40.5	32.0 ± 1.1	21.0—49.0	33.6 ± 1.5
(5) No. of seeds/capsule	27—74	46 ± 4.0	9—58	38 ± 3.3
(6) Weight of seeds/capsule	0.09—0.23	0.15 ± 0.01	0.03—0.20	0.12 ± 0.02
(7) 1000 — seed wt. (g)	2.77—3.57	3.16 ± 0.1	1.80—3.56	2.9 ± 0.2
(Y) Yield/acre (kg)	118—608	320 ± 47	30—382	212 ± 50.1
(O) Oil content (%)	51—58	54.1 ± 0.5	51—55	53.4 ± 0.4

* Characters code (1, 7 and Y, O) presented in this table are consistantly used in other tables.

Partial regression coefficients

In this study, partial regression coefficients were worked out separately for yield and oil contents (as dependent variables) in both of the F_1's and the parental groups. In all, 42 coefficients, 6 for each character (e.g. b_y 1.2, b_y 1.23, b_y 1.234, b_y 1.2345, b_y 1.23456 and b_y 1.234567, for plant height) were worked out for each set of data. Of these the only significant coefficients are presented in Tables 2 and 3.

Out of the 84 partial regression coefficients computed for seed yield, only 14 coefficients (5 in the F_1's group and 9 in the parental group) were significant (Table 2). Among these, coefficients of yield with number of capsules per plant

Table 2

Partial regression coefficients of yield (Y) and some agronomic characters in 11 sesame hybrids and their parents

Code	Partial coefficient	S. E.	F-value
	Hybrids		
b_y 2.1	—4.3	1.2	17.7**
b_y 3.1	6.6	1.3	24.5**
b_y 4.1	17.1	6.2	7.6*
b_y 5.1	8.3	1.8	22.1**
b_y 6.1	2192	542	16.3**
	Parents		
b_y 3.1	3.5	0.7	23.9**
b_y 3.12	3.6	1.0	13.1**
b_y 3.124	3.6	1.1	10.8*
b_y 3.12456	3.7	1.2	8.7*
b_y 5.1	6.5	2.4	7.5*
b_y 5.12	5.8	2.1	7.5*
b_y 6.1	2985	577	26.8**
b_y 6.12	2739	689	16.8**
b_y 6.12345	2985	1457	12.0*

* and ** significant at 5 and 10% levels, respectively.

(b_y 3.1), independent of plant height, had the highest F-values and the minimum standard error in both the F_1's and the parental group. Coefficients of seed yield with number of seeds per capsule (b_y 5.1 = 8.3) in the F_1's and of weight of seeds per capsule (b_y 6.1) in both the F_1's and the parents, independent of plant height, were also highly significant ($P = 0.01$). This indicates the number of capsules per plant as well as the number and weight of seeds in these capsules were the most important yield contributing characters. Among these, the number of capsules seemed to be the most important. This is in accordance with Sikka and Gupta (1949), Osman and Khidir, (1974a) all of whom emphasized the importance of the number of capsules per plant in the same selection programmes.

Apart from the coefficients with number and weight of seeds per capsule (Table 3), none of the partial regression coefficients computed for oil content in either the F_1's or the parental group was significant. However, since both these characters had an opposing effect on oil content, a compromise must be reached in selecting both these two traits if maximum oil content is to be obtained.

Table 3

Partial regression coefficients of oil content (O) and some agronomic characters in 11 sesame cultivars

Code	Partial coefficient	S. E.	F-value
b_y 05.12346	—0.45	0.10	19.3**
b_y 05.123467	—0.50	0.51	71.9**
b_y 06.123467	136.19	34.59	15.50*
b_y 06.123467	137.85	19.22	57.41**

* and ** significant and 5 and 1% levels respectively.

Multiple correlations

In this study, multiple correlation coefficients (R) were worked out separately for yield/acre and oil content in both the F_1's and the parental group. All R-values computed for yield except for R_y. 1234567 in the F_1's were significant. On the other hand, all R-values computed for oil content, except for RO. 1234567 in the parent group were insignificant (Table 4). Coefficients of

Table 4

Multiple correlation coefficients of yield (Y) and oil content (O) and seven agronomic characters in 11 sesame hybrids and their parents

Code+	Multiple correlation coefficient			
	Seed yield (Y)		Oil content (O)	
	Hybrids	Parents	Hybrids	Parents
R_y 12	0.868**	0.926***	0.579	0.392
R_y 123	0.928**	0.975***	0.639	0.467
R_y 1234	0.939**	0.975***	0.663	0.628
R_y 12342	0.944**	0.976***	0.680	0.703
R_y 123456	0.963**	0.994**	0.725	0.747
R_y 1234567	0.974	0.995*	0.841	0.988*

+ in reading coefficients for oil content, replace y by 0.
*, ** and *** significant at 5, 1 and 0.1% levels respectively.

determination (R^2) ranged from 75.4** to 94.9 in the F_1's and from 85.7*** to 98.9* in the parental group, indicating that most of the variability in yield can be accounted for by its association with the 7 characters included in this study. However, among these characters the number of capsules showed to be the most important.

Multiple regression

Of the many multiple regression equations worked out, only those that had the highest F-values, minimum standard error, lowest number of characters combination and comparatively the highest R^2-values were selected and are presented in Table 5. At this level, coefficients of determination indicated that about 87.2** and 95.0*% of the variability in the mean yield was accounted for by its association with plant height and number of capsules per plant in the F_1's and their parents, respectively, indicating the reliability of these traits in selecting high yielding strains.

Table 5

Selected regression models for yield and oil content for 11 sesame hybrids and their parents

Model code	Measure	Regression	R^2
	Kg/acre	Seed yield	
F_1's	320 ± 66.7	$y = 1158.1 + 6.6X_4 - 4.9X_1$	0.872**
Parents	212 ± 41.9	$y = 543.0 + 3.5X_4 - 2.4X_1$	0.950***
		% Oil content	
F_1's	54.1 ± 1.40	$O = 60.8 + 0.045X_4 - 0.037X_1$	0.409 n.s.
Parents	53.4 ± 0.85	$O = 52.7 + 0.005X_1 + 86.16X_7 - 0.282X_6$	0.725*

*, ** and *** significant at 5, 1 and 1% levels, respectively.
Note: characters: X_1, X_4, X_6 and X_7 are the same as 1, 4, 6 and 7 in Table 1.

Regression models worked out for oil content revealed that about 72.5*% of the variability in this character in the parental group was associated with plant height, number and weight of seeds per capsule. None of the various character combinations evaluated in the F_1's had a significant contribution in the variability associated with oil content. This is expected, since oil content has a low heritability estimates (Osman and Khidir, 1974b) and is highly effected by the environment (Kluijver and Smilde, 1960; Kinman and Stark, 1954; Singh et al. 1960). Hence in assessing inter-relationships involving oil content, other characters — both vegetative (e.g. leaf area, petiole length) and environmental factors (e.g. day length, days of the growing season) should be considered.

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Acta Agronomica Hungarica 37 (3—4), pp. 293—299 (1988)

EFFECT OF MUTAGEN TREATMENTS ON POLLEN STERILITY IN PEAS (*PISUM SATIVUM* L.)

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(Received: 21 May 1986; accepted 20 October 1986)

The experiment was aimed at studying the modifying effect of different dates of gamma radiation and EMS treatment on pollen sterility in various pea varieties, with special regard to producing male sterile forms for use as basic material in cross-breeding.

Under the influence of mutagen treatments the frequency of sterile pollen increased in both varieties examined. In the variety Gloria di Quimper for example, the proportion of sterile pollen grains in the control was $1.35 \pm 1.2\%$, while in the 15kr gamma radiation treatment it was $50.12 \pm 3.1\%$.

With a gamma radiation rate of 15kr, the pollen sterility of some plants in both varieties examined ranged between 30.0 ± 0.3 and $62.4 \pm 1.5\%$. Completely sterile plants were not found.

In the radiation garden at Szigetcsép — with CO^{60} of 150 Curie activity as source of radiation and a distance of 5 m between the source and the plants — irradiation resulted in a slight increase in the percentage of sterile pollen, compared to the control both in the M_1 and M_2 generations of pea varieties examined.

On repeated examinations of pollen sterility in the M_2 generation with different mutagen treatments, it was found that the proportion of sterile pollen grains in the M_2 generation considerably decreased, compared to the M_1 generation.

Keywords: EMS treatment, gamma radiations, mutagen treatments, pollen sterility, pea varieties

Introduction

Crossing is peas is an extremely complicated procedure. The pea is a self-fertile plant; the anthers dehisce before the buds open, and so pollination and fertilization take place even before blooming. The work of crossing would be easier if male sterile forms were available.

Male sterility with the simultaneous fertility of the female sexual organs often occurs in wild plants. This fact suggests that this condition can be brought about artifically.

The question to be answered by the experiments described below was whether, in the case of the self-fertile pea plant, male sterile forms could be produced.

Accounts of our results have already been given in several publications. The present paper deals with some applications of gamme irradiation (seed treatment, sowing in the radiation garden) and with the effect of various rates of EMS treatment on some pea varieties.

For some decades a number of publications have dealt with studies on pollen sterility, mainly in tomato, cereals and sunflower. Experiences have shown an increase in the proportion of sterile pollen in the above plants in response to mutagen treatments; in some cases pollen sterility reached 100% (Rich 1948, 1975, Barabás 1961, 1962, Kurnik et al. 1962, Phatak et al. 1966, Kasembe 1967, Lapushner et al. 1967, Kapás 1969, Philouze 1969, 1974. Bozzini 1974, Driscoll et al. 1976, Sadakuma et al. 1978, and Ramage 1981).

On methods of inducing sterility in peas, few literary data have been published so far.

Speckmann (1964) treated the pea seeds with EMS solution for 24 hours at various temperatures. When examining the progeny, he found that the frequency of fertile plants increased with the temperature of treatment.

Graskina et al. (1960) produced sterile mutants with neutron flux (in Kurnik 1969).

Tamássy et al. (1967) found that, of all treatments applied, only the 30-minute neutron radiation induced sterility in the pea variety Rondo. From seeds treated with 0.5% solution of ethyl-methane sulphonate (EMS) Tamássy obtained some plants with partial pollen sterility.

Wellensiek (1964) studied the fertility of peas in M_2 generations obtained from different mutagen treatments and found that, with the increase of dose, fertility decreased.

According to our data, gamma radiation was the most effective of the three treatments in increasing sterility, followed by the X-ray and then by the EMS treatment (Vo Hung 1973).

The effect on fertility of the mutagens described in the literature was chosen as the subject of our investigations with all the above taken into consideration, and special attention was paid to the character and extent of a possible male sterility.

Material and methods

The experiments were set up at the Department of Plant Genetics and Breeding of the University of Horticulture.

Mutagen treatments

(1) Dry seeds treated with 5, 10, 15 and 20 kr gamma radiation*. The treatments were carried out at the Laboratory of the Isotope Institute of the Hungarian Academy of Sciences.

(2) Dry seeds treated with 0.1, 0.3 and 0.5% solutions of ethyl-methane sulphonate (EMS) for 12 hours.
The pea varieties used were: "Gloria di Quimper" (round seeded) and "Erika" (marrowfat).

(3) Pea varieties sown in the Szigetcsép radiation garden: "Gloria di Quimper", "Express", "Debreceni világos zöld" (round seeded peas), "Viridis", "Erika" (marrowfat peas). The source of radiation was: CO^{60} with 150 Curie activity; the distance between the source and the plants: 5 m.

* 80 r/minute intensity

For pollen examinations, fully developed flowers were collected. The viability of the pollen was determined by the carmine acetic acid staining method. Pollen grains, if full of plasm and stained red, were regarded as fertile, in the opposite case they were sterile. The number of pollen grains was determined in 10 fields of vision for each preparation.

With 5 preparations $\times$ 10 fields of vision, a total of 50 data per variety and dose were obtained.

Results

Pollen sterility in the M_1 and M_2 generations

The frequency data of sterile pollen are given in Table 1. In the M_1 generation of the variety Gloria di Quimper, the proportion of sterile pollen was $1.35 \pm 1.2\%$ in the control and $50.12 \pm 3.1\%$ in the 15 kr gamma radiation treatment.

Under the influence of mutagen treatments, the frequency of sterile pollen increased in both varieties examined. The difference is statistically reliable.

The two varieties examined did not much differ in the effect of mutagen treatments.

With repeated examinations of the M_2 generation in the above treatments the following results were obtained: the proportion of sterile pollen considerably decreased compared to that in the M_1 generation, and was only in some cases higher than in the control.

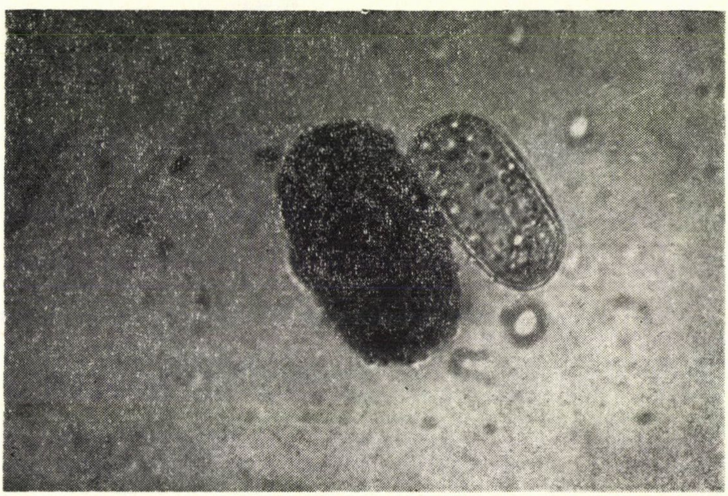

Fig. 1. "Gloria di Quimper", fertile (left) and sterile (right) pollen (gamma 15 kr). Blow-up: $\times 1800$

Table 1

Pollen sterility induced by gamma radiation and EMS treatment in population

Treatment	Fertile (n)	Sterile (n)	Total examined pollen (n)	Sterile pollen, %
M_1 generation (1985) Variety: "Gloria di Quimper"				
Control	1574	21	1595	1.35±1.2
gamma 5 kr	1020	146	1166	12.26±2.8***
gamma 10 kr	1017	421	1438	29.24±3.3***
gamma 15 kr	798	814	1642	50.12±3.1***
EMS 0.1%	1165	104	1269	8.19±1.8**
EMS 0.3%	1051	315	1366	23.06±2.2***
EMS 0.5%	926	322	1248	25.80±2.1***
M_1 generation. Variety: "Erika"				
Control	1485	17	1502	1.14±0.8
gamma 5 kr	1078	106	1184	8.95±2.9*
gamma 10 kr	915	455	1370	33.21±2.6***
gamma 15 kr	824	602	1426	42.21±3.4***
EMS 0.1%	1361	95	1456	6.52±1.9*
EMS 0.3%	1124	291	1412	20.60±1.2***
EMS 0.5%	724	368	1062	33.69±2.1***
M_2 generation (1986) Variety: "Gloria di Quimper"				
Control	1344	15	1359	1.11±0.6
gamma 5 kr	1228	72	1300	5.86±2.5
gamma 10 kr	1423	66	1489	4.43±1.8
gamma 15 kr	1086	80	1166	6.86±2.6*
EMS 0.1%	1318	77	1395	5.51±2.4
EMS 0.3%	992	40	1032	3.87±2.0
EMS 0.5%	1501	98	1599	6.12±2.2*
M_2 generation. Variety: "Erika"				
Control	1196	13	1209	1.07±0.7
gamma 5 kr	1422	74	1496	4.95±2.0
gamma 10 kr	1014	72	1086	6.62±2.2*
gamma 15 kr	1218	88	1306	6.73±2.8
EMS 0.1%	921	54	975	5.53±2.5
EMS 0.3%	1371	82	1453	5.64±2.0*
EMS 0.5%	1125	75	1200	6.25±2.7

*: The difference at P = 5% is significant.
**: The difference at P = 1% is significant.
***: The difference at P = 0.1% is significant.

Correlation coefficient and linear regression equation for pollen sterility % (in generation M_1) and rate of gamma radiation:

$$r_{xy} = +0.90^*$$
$$Y' = 0.91 + 2.98X^*$$

The difference is significant (P = 10%)

Examination of pollen sterility in gamma irradiated plants of the M_1 generation

With a 15 kr dose of gamma radiation pollen sterility in the M_1 generation was $50.12 \pm 3.1\%$ in the variety Gloria di Quimper and $42.21 \pm 3.4\%$ in the Erika. Individual plants of the varieties Gloria di Quimper and Erika were also examined for pollen sterility. Ten plants per variety were chosen at random and given 15 kr gamma radiation. From each of them, 5 flowers were collected and determined for sterility percentage. The aim was to find out whether there was any plant that showed 100% pollen steriliy.

As seen in Table 2, pollen steriliy in the above varieties ranged between 30.0 ± 2.3 and $62.4 \pm 1.5\%$. Completely sterile plants were not found in either of the two varieties, only semi-sterile ones were produced.

Co^{60} induced pollen sterility (in radiation garden)

In response to irradiation with Co^{60}, the frequency of sterile pollen grew slightly both in the M_1- and M_2 generation of the pea varieties sown in the radiation garden. In the variety Gloria di Quimper for example, the proportion

Table 2

Gamma radiation induced pollen sterility in some plants

Treatment	Fertile (n)	Sterile (n)	Total examined pollen (n)	Sterile pollen, %
Variety: "Gloria di Quimper" Treatment: gamma 15 kr				
1	525	411	936	43.9 ± 1.9
2	478	605	1083	55.8 ± 1.4
3	622	487	1109	43.9 ± 2.6
4	408	680	1088	62.4 ± 1.5
5	812	703	1515	46.4 ± 2.2
6	502	588	1090	56.6 ± 1.1
7	495	555	1050	53.3 ± 3.0
8	628	414	1042	39.6 ± 1.5
9	785	337	1122	30.0 ± 2.3
10	708	906	1614	56.1 ± 1.8
Variety: "Erika" Treatment: gamma 15 kr				
1	723	514	1237	41.5 ± 2.1
2	627	805	1432	55.4 ± 1.4
3	516	442	998	44.2 ± 2.7
4	625	401	1026	39.0 ± 1.9
5	802	644	1446	44.5 ± 3.0
4	625	401	1026	39.0 ± 1.9
5	802	644	1446	44.5 ± 3.0
6	574	801	1375	58.4 ± 1.8
7	877	501	1378	43.6 ± 1.2
8	912	490	1402	34.9 ± 3.1
9	466	584	1050	55.6 ± 1.1
10	668	804	1474	54.5 ± 2.4

Table 3

^{60}Co radiation induced pollen sterility in population in radiation garden

Variety	Fertile	Sterile	Total	Sterile
		M_1 generation (1985)		
"Gloria di Quimper"	1355	33	1388	2.37 ± 1.8
"Express"	1014	38	1052	3.61 ± 1.6
"Debreceni világoszöld"	1265	55	1320	4.16 ± 1.1
"Viridis"	1426	39	1465	2.66 ± 1.4
"Erika"	978	46	1024	4.49 ± 1.19
		M_2 generation (1986)		
"Gloria di Quimper"	1022	21	1043	2.01 ± 1.5
"Express"	1136	21	1157	1.81 ± 1.3
"Debreceni világoszöld"	1380	26	1406	1.84 ± 1.0
"Viridis"	988	24	1012	2.37 ± 1.9
"Erika"	1414	30	1444	2.07 ± 1.6

of sterile pollen in the M_1 generation was $1.35 \pm 1.2\%$ in the control (field experiment), and $2.37 \pm 1.8\%$ in the Co^{60} treatment, while in the M_2 generation it was $1.33 \pm 1.1\%$ in the control and $2.11 \pm 1.5\%$ in the Co^{60} treatment.

Summary

The modifying effect on pollen sterility of different rates of gamma radiation- and EMS treatments was studied with various pea varieties, with special regard to producing male sterile forms and using them as basic material in cross breeding.

From the results the following conclusions can be drawn:

(1) Under the influence of various doses of gamma radiation and concentrations of EMS, the frequency of sterile pollen in the varieties included in the experiment remarkably increased.

The percentage of sterile pollen in the M_2 generation compared to the M_1 generation considerably decreased, and was only in some cases higher than in the control.

(2) Close positive correlation was found between the percentage of pollen sterility and the rate of gamma radiation ($r_{xy} = +0.90$).

(3) With a 15 kr dose of gamma radiation pollen sterility in some plants of the two varieties examined (Gloria di Quimper and Erika) ranged between 30.0 ± 0.3 and $62.4 \pm 1.5\%$. Completely sterile plants were not found.

(4) In the radiation garden the frequency of sterile pollen in the M_1 and M_2 generations of the pea varieties examined slightly increased, compared to the control in response to Co^{60} irradiation.

To decide the applicability of the treatment in the practice of breeding, further repeated experiments and observations of the progeny are required.

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Acta Agronomica Hungarica 37 (3–4), pp. 301–310 (1988)

Agrochemistry

MICRONUTRIENTS IN SOME VINEYARD SOILS OF ANDALUSIA (SPAIN)

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(Received 3 February 1987; accepted 7 April 1987)

In this work we have studied the values of general chemical parameters, microelements and cationic macroelements in the three types of viticultural soils (four rendsines, four vertisols and four red soils) most representative encountered in the Montilla-Moriles area, located in Andalusian (southern Spain). We made an arithmetical mean profile for each type of soil, and discussed the variation of such parameters with depth, as well as the possible deficiencies in micronutrients. One factorial analysis obtained from these three factors allows us to realize a dispersion diagramme indicating three groups of samples that coincide with the three types of selectioned soils. Finally, we have carried out a statistical treatment which has allowed us to determine the depth below which these soils offer the plant a nutritional support which is not dependent on the types of soil in question, but rather on the calcareous substrate analogous throughout the area.

Keywords: soil, micronutrients, viticulture

Introduction

The viticultural zone bearing the "appellation d'origine" Montilla-Moriles lies in the southwest of the province of Cordoba (Spain) and comprises part of the following natural regions: Campina Alta, Campina Baja and Region Subética. Its overall extension is about 170.000 ha. This zone, featuring a large variety of geological profiles (Quaternary, Tertiary and Secondary), is however characterized by the uniformity of its rock substrate, consisting of calcareous materials weathered and consolidated to a varying extent which results in different pedological formations — especially rendsines, vertisoles and red soils.

We should also mention the almost absolute prevalence of *V. vinifera* (Pedro Ximénez) over other types of grapevine. Other environmental features of this zone were profusely described elsewhere (Sánchez et al., 1983).

Following earlier works which involved characterizing the typical grape of this zone (Moreno et al., 1983), we have studied the micronutrient contents of these viticultural soils, as well as their relationship to general chemical parameters and macronutrients, thus contributing new data which include their possible deficiencies in order to gather valuable information to be used in subsequent studies on the fertilization and mineral nutrition of the grapevine which produce the desired wine varieties under the particular conditions of this viticultural region.

Material and methods

We have studied 12 viticultural soil profiles —4 samples of each of the following types: rendsines, vertisols and red soils. Samples were taken at five different depths (0–25 cm, 25–50 cm, 50–75 cm, 75–100 cm and 100–125 cm) since according to Branas and Vergnes (1957), grapevine roots usually go no deeper than 125 cm in the ground — occasionally, some of them may reach dephts of 3–4 m.

All samples were analyzed for the following parameters: pH in paste saturated with H_2O or KCl, percentage CO_3, percentage organic matter (Sims and Haby, 1971), total and available microelements (Pinta, 1971), percentage free ioxides (Endrey, 1963), and total (Pinta, 1971) and available macroelements (G.T.N.M.A., 1976). In addition, every sample was subjected to a mechanical analysis (Primo Yufera, 1973).

From the results we obtained an average profile for every type soil and performed a factor analysis of main components as described in an earlier paper (Moreno et al., 1984).

Finally, we adopted the criteria of Sneath and Sokal (1973) to obtain the similarity index dendrograms for all twelve soils studied at each of the five depths taken, considering all the variables determined.

Results and discussion

In Table 1 are listed the values obtained for the general chemical parameters determinend for the average profile of each of the three soils.

Table 1

General parameters of soils

Soil type	Profile (cm)	pH (H_2O)		pH (ClK)		%O.M.		$\%CO_3^-$		CEC (meq · kg^{-1})	
		$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Rendsines	0–25	7.3	7.2–7.5	6.5	6.4–6.8	1.0	0.7–1.3	32.0	23.0–39.1	194	80–302
	25–50	7.4	7.3–7.6	6.5	6.4–6.8	0.8	0.7–0.1	32.4	23.4–39.8	198	91–321
	50–75	7.5	7.4–7.5	6.4	6.3–6.5	0.5	0.3–1.0	31.7	21.2–40.6	192	42–302
	75–100	7.5	7.3–7.8	6.5	6.3–56.6	0.4	0.2–0.7	31.1	21.8–40.8	209	49–304
	100–125	7.5	7.4–7.5	6.5	6.3–6.6	0.3	0.2–0.7	30.7	19.3–42.5	181	35–295
Red soils	0–25	7.6	7.3–7.9	6.5	6.3–6.6	1.6	1.1–2.1	13.1	9.0–30.7	231	190–287
	25–50	7.6	7.3–7.9	6.5	6.4–6.6	1.4	0.8–1.8	16.2	3.1–26.8	214	121–262
	50–75	7.6	7.3–7.8	6.5	6.3–6.6	1.0	0.5–1.3	25.0	8.8–40.7	184	102–230
	75–100	7.7	7.4–7.9	6.6	6.4–7.0	0.9	0.5–1.0	32.6	15.8–44.6	147	41–275
	100–125	7.7	7.4–8.0	6.7	6.5–7.2	0.5	0.3–0.7	34.8	16.0–45.7	123	22–232
Vertisols	0–25	7.4	7.1–7.9	6.4	6.2–6.6	1.3	0.9–1.8	16.8	14.8–19.9	324	210–435
	25–50	7.4	7.3–7.6	6.4	6.3–6.7	1.0	0.9–1.3	16.8	14.9–20.0	333	255–403
	50–75	7.4	7.4–7.4	6.5	6.4–6.5	0.8	0.6–0.9	16.5	12.5–20.9	317	249–358
	75–100	7.5	7.4–7.5	6.5	6.4–6.6	0.8	0.5–0.9	16.1	11.5–21.8	305	206–349
	100–125	7.5	7.4–7.6	6.6	6.5–6.6	0.7	0.3–0.8	17.6	14.3–25.9	296	289–327

As can be seen, the pH increases with increasing depth to a value of 7.5 and 6.5 in water-saturated and KCl-saturated paste, respectively. As regards the carbonate content, this is very similar in vertisols and red soils taken from surface layers, whereas this similarity is grater between red soils and rendsines at greater depths.

The organic matter contenet is somewhat low — it is less than 2% in every case —, consistent with the agricultural exploitation of this type of soil. The cation-exchange capacity is greatest for vertisols — approximately 300 $meq \cdot kg^{-1}$ — due to their finer texture and decreases remarkably with increasing depth in red soils.

Finally, the texture of these soils is virtually loam for rendsines, clay loam for red soils and clay for vertisols (FAO, 1977).

In Table 2 are shown the contents in cationic macroelements — both total and available.

We should note the higher content in the available fraction of these elements in vertisols, as well as the decrease with increasing depth in red soils — rendsines have a relatively uniform content in these elements regardless of depth. It is also worth noting that CaO is the prevalent oxide of these soils whilst K_2O and MgO are found in similar amounts.

In Table 3 are listed the contents in total and available microelements, free iron and manganese.

As can be observed, the overall and the free iron contents evolved in much the same fashion and tend to decrease with greater depth in red soils, increasing or remaining virtually constant in rendsines and vertisols. As regards the ratio of total-to-free iron, this is highest for red soils (close to 30% near the surface), followed by vertisols (15–20%) and rendsines (5–7%). Such ratios are not so high as might be expected, especially for red soils, owing to their high pH and carbonate content, which allows classing them as fersialytic brown soils (Duchaufour, 1977) since they are not completely lubricated and they do not generally exceed the 5YR range of Munsell's key.

The contents in available iron are rather low as compared with the overall amount of iron found. The lowest values are obtained for red soils, in agreement with their higher pHs. Moreover, taking into account that these soils are the most frequent medium for ferric chlorosis in the Montilla–Moriles region, we have set an amount between 5–7 $mg \cdot kg^{-1}$ of Fe extracted with EDTA as the critical value for cultivation in this viticultural zone.

Regarding the contents in the different fraction of manganese (Table 3.), there are remarkable differences between the soils studied. Thus, the highest contents in the total and free fractions are found in vertisols, followed by red soils and rendsines. The evolution of the available fraction with depth is similar in rendsines and vertisols, whereas it decreases sharply in red soils. Nevertheless, the values found seem to rule out the deficiency in this element.

Table 2

Contents in total cationic macroelements

Soil type	Profile (cm)	% CaO		% MgO		% K_2O	
		$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Rendsines	0–25	21.4	13.9–27.7	1.0	0.6–1.3	1.0	0.4–2.2
	25–50	21.1	15.0–24.4	0.9	0.7–1.2	0.9	0.2–1.8
	50–75	19.7	13.3–25.5	1.1	0.8–1.3	1.7	0.6–4.4
	75–100	20.8	13.5–27.2	1.1	0.9–1.4	1.1	0.4–1.7
	100–125	18.4	11.7–24.1	1.3	1.0–1.6	1.0	0.3–2.1
Red soils	0–25	9.8	1.4–20.8	1.0	0.6–2.0	2.0	1.1–2.7
	25–50	11.6	2.1–22.2	1.0	0.6–2.1	2.1	1.1–2.9
	50–75	15.0	5.0–27.9	1.0	0.5–1.8	1.9	1.0–2.5
	75–100	18.9	10.0–25.0	0.9	0.3–2.2	1.6	0.7–2.6
	100–125	20.4	9.3–26.3	0.9	0.2–2.3	1.9	0.5–3.8
Vertisols	0–25	10.9	9.6–12.2	1.5	1.1–1.9	2.2	1.7–2.7
	25–50	11.4	10.2–11.9	1.5	1.0–1.9	2.4	1.9–2.6
	50–75	11.4	7.0–13.9	1.5	1.1–1.9	2.4	2.1–2.6
	75–100	10.9	6.8–13.8	1.4	1.1–1.8	2.2	1.9–2.6
	100–125	10.8	5.9–16.1	1.4	1.0–2.0	2.8	2.0–3.8

Table 2 (cont.)

Contents in available cationic macroelements (mg/100 g soil)

Soil type	Profile (cm)	CaO		MgO		K_2O	
		$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Rendsines	0–25	825.3	638–1002	13.5	8–51	21.8	12–42
	25–50	822.0	630–998	11.3	6–37	13.0	7–20
	50–75	845.2	621–1006	11.3	7–45	11.7	5–19
	75–100	859.3	630–1010	12.3	7–61	12.1	4–17
	100–125	875.6	638–1087	14.8	5–100	13.9	5–20
Red soils	0–25	816.6	748–953	23.8	14–51	38.0	14–59
	25–50	875.9	770–980	16.5	12–55	28.3	11–59
	50–75	789.7	695–898	12.6	11–86	18.7	9–29
	75–100	730.3	625–800	9.7	5–12	11.9	5–23
	100–125	716.2	568–804	7.7	3–13	9.1	2–17
Vertisols	0–25	995.3	910–1162	72.3	40–112	43.6	25–58
	25–50	983.2	849–1180	76.0	38–129	30.5	22–39
	50–75	993.7	840–1180	94.7	47–136	24.4	21–30
	75–100	964.3	796–1133	108.9	61–155	25.8	20–36
	100–125	920.1	695–1027	138.2	84–187	23.5	17–37

Table 3

Contents in total microelements of soil [(Fe_2O_3) (%), Mn, Cu and Zn ($mg \cdot kg^{-1}$)]

Soil type	Profile (cm)	Fe_2O_3		Mn		Cu		Zn	
		$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Rendsines	0–25	2.5	1.0–3.6	293.3	146–405	36.9	8–73	428.5	326–641
	25–50	2.5	1.6–3.5	274.5	227–310	34.3	8–65	370.9	295–412
	50–75	2.7	1.9–3.5	297.2	258–352	28.4	5–25	444.4	371–561
	75–100	2.4	1.3–3.5	291.0	225–427	26.5	1–62	354.4	310–398
	100–125	3.0	1.5–5.3	341.5	212–599	16.4	1–39	360.5	312–455
Red soils	0–25	4.5	2.4–6.1	596.0	289–734	41.8	30–56	374.5	304–417
	25–50	3.7	2.9–4.6	490.4	313–622	36.2	19–45	340.4	309–381
	50–75	3.3	3.0–3.6	455.2	365–610	29.5	18–50	324.9	308–362
	75–100	3.1	2.0–5.0	497.6	318–659	32.9	19–51	316.6	270–352
	100–125	3.8	3.0–4.9	501.2	365–696	32.4	10–53	309.7	270–357
Vertisols	0–25	3.7	3.2–4.2	813.5	341–958	45.8	30–57	326.8	260–374
	25–50	4.0	3.1–4.7	829.2	498–939	38.3	25–50	305.4	233–336
	50–75	4.0	3.4–4.4	834.8	533–1011	39.2	20–49	332.1	295–371
	75–100	4.5	3.6–6.8	996.8	503–1115	32.0	19–42	338.1	319–368
	100–125	4.4	3.0–5.6	880.1	549–1084	31.5	20–39	336.3	293–393

Table 3 (cont.)

Contents in available ($mn \cdot kg^{-1}$) and free (%) micronutrients of soil

Soil type	Profile (cm)	Fe		Mn		Cu		Zn		Fe_2O_3		$MnO \cdot 10^3$	
		$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Rendsines	0–25	8.7	4–17	5.8	7–10	2.1	1–3	2.1	2–3	0.2	0.4	0.9	1.8
	25–50	8.2	4–18	6.0	5–8	1.5	1–2	1.6	1–2	0.2	0.4	0.8	1.3
	50–75	8.3	4–18	5.7	5–7	0.6	0–1	1.5	1–2	0.2	0.3	0.8	1.2
	75–100	7.6	4–14	6.3	3–9	0.5	0–1	2.2	1–3	0.1	0.3	0.9	1.4
	100–125	8.1	4–19	5.9	3–8	0.3	0–1	1.4	1–2	0.2	0.3	1.1	1.7
Red soil	0–25	6.7	5–8	19.6	10–30	2.2	1–3	1.8	1–2	1.1	2.0	2.8	3.9
	25–50	6.4	5–8	11.1	8–16	0.6	0–1	1.3	1–2	1.0	1.5	2.9	4.8
	50–75	6.4	5–9	8.4	5–12	0.5	0–1	1.3	1–2	1.0	1.3	2.4	8.8
	75–100	5.5	4–7	6.1	4–10	0.3	0–1	1.1	1–2	0.5	1.2	2.1	3.8
	100–125	4.7	4–7	5.8	2–8	0.1	0–1	1.2	1–2	0.4	1.2	1.9	3.7
Vertisols	0–25	9.7	4–11	14.0	10–23	2.5	2–3	1.5	1–2	0.7	1.6	6.0	15.5
	25–50	9.3	4–14	13.2	9–19	1.6	1–2	1.3	1–2	0.6	1.7	6.1	15.7
	50–75	8.2	4–13	10.9	9–13	0.9	0–1	1.1	1–2	0.7	1.4	6.2	16.1
	75–100	9.7	5–12	11.6	8–18	0.9	0–1	1.1	1–2	0.8	1.2	6.6	16.7
	100-125	6.5	7–16	9.3	7–13	0.8	0.1	1.1	1–2	0.8	1.1	6.6	17.8

The copper contents, which decrease with increasing depth, are similar for all three types of soils. This is logical if one considers the continuous replenishment of this element through the use of phytochemicals.

The zinc contents are slightly higher in rendsines than in the other two types of soils. The fraction of available zinc ranges between 1–2 $mg \cdot kg^{-1}$. Surface layers show higher contents. This range can be considered critical for culture soils in general (Trierweiler and Lindsay, 1969), and for vine growing soils in particular (Khetawat and Vashista, 1977), although the response of grapevine to this element is not very clear (Lucas and Knezek, 1983).

The above-mentioned values were used to build a data matrix of 24 columns (one for each of the variables studied: pH in H_2O and KCl, % O.M., % CO_3, CCC, % clay, % slime, % sand, % free Fe_2O_3 and MnO, total Fe, Cu, Mn, Zn, Ca, Mg and K, and available Fe, Cu, Mn, Zn, Ca, Mg and K) and 15 rows (one per type of soil and depth).

The next step involved constructing the corelation matrix (24×24) and diagonalizing the 'eigenvalues' corresponding to each of the resulting 24 components. Then, we selected the first three components whose 'eigenvalues' exceeded unity and subjected them to the varimax rotation (Kaiser, 1958).

The rotated components will henceforward be referred to as factors and have the factored weights in each variable listed in Table 4. Factors I, II and III account for 33.06%, 17.73% and 29.60% of the variance, respectively, i.e. 80.39% of the overall variance altogether, which is more than acceptable (Diday et al., 1982).

The criterion chosen to assign the variable to each factor involved those having the highest weights.

Next we calculated the score of every sample for each of the factors, subsequently running a graph of the scores corresponding to the different depths of the average profiles considered (Fig. 1). This involved assigning Factors I and II to the x- and y-axis, respectively.

As reflected in the graph, there are three distinct groups of samples corresponding to each of the types of soils studied. The first group, comprising the five depths of the average profile of rendsines, bears the highest positive score with respect to Factor I. This type of soil is the least evolved and has a more marked mineral character — which is logical, taking into account that it generally results from the erosive weathering of earlier soils. On the other hand, vertisols are the most evolved, as reflected in their score — the lowest — with respect to Factor I. Red soils show an intermediate state of evolution.

With regard to Factor II, it is red soils which show the highest score, which seems to indicate the availability of less iron for plants and hence the greater likeliness of ferric chlorosis.

Factor III is somewhat complementary of Factor I. As can be observed, rendsines have negative scores for depths below 25 cm, which is indicative of a

Table 4

Factorial weights of the variables

	Factor I	Factor II	Factor III
1. pH (H_2O)	—0.16	0.71	—0.22
2. pH (ClK)	—0.19	0.62	—0.50
3. % O.M.	—0.09	0.21	0.93
4. % CO_3	0.69	0.16	—0.64
5. % Clay	—0.14	—0.64	—0.47
6. % Silt	0.50	—0.57	—0.35
7. % Sand	—0.20	0.65	0.44
8. % Fe_2O_3 free	—0.63	0.29	0.52
9. % MnO free	—0.83	0.27	0.31
10. % Fe_2O_3 total	—0.86	0.04	0.40
11. Cu total	—0.09	0.02	0.93
12. Mn total	—0.86	—0.19	0.31
13. Zn total	0.87	—0.28	0.07
14. % CaO total	0.74	0.10	—0.60
15. % MgO total	—0.57	—0.69	0.13
16. % K_2O total	—0.89	—0.01	0.32
17. Fe available	—0.16	—0.72	0.13
18. Cu available	0.03	—0.33	0.84
19. Mn available	—0.33	—0.06	0.91
20. Zn available	0.87	—0.21	0.26
21. CaO available	—0.45	—0.61	0.32
22. MgO available	—0.78	—0.42	0.20
23. K_2O available	—0.34	—0.17	0.89
24. C.E.C.	—0.55	—0.50	0.45
% Variance	33.06	17.73	29.60
% Overall Variance	33.06	50.79	80.39

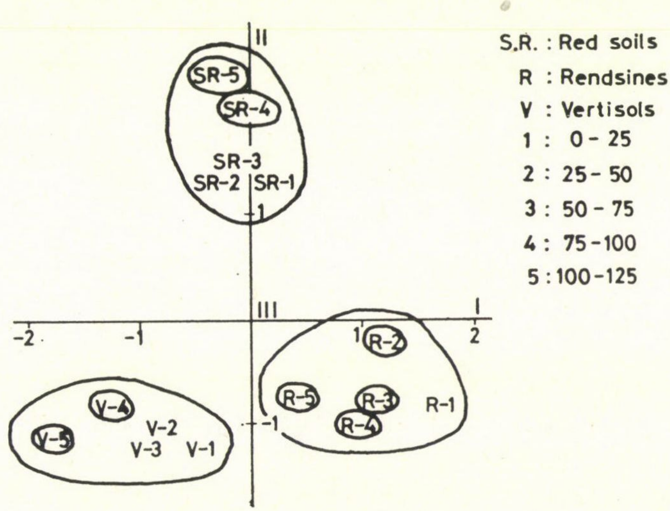

Fig. 1

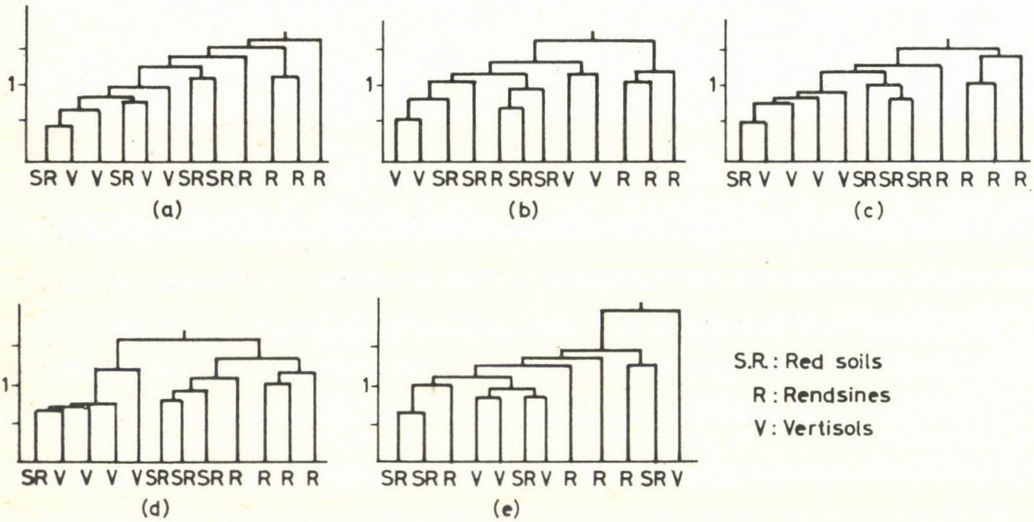

Fig. 2

more marked mineral character than that exhibited by red soils or vertisols, whose scores in this factor are only negative at depths below 75 cm.

Finally, we analyzed the similarity indices (cluster) for every soil studied (4 rendsines, 4 vertisols and 4 red soils) at each depth considered.

The dendrogram obtained for the surface layer (Fig. 2a) reveals the greater similarity between vertisols and red soils, i.e. the more evolved soils.

The dendrograms corresponding to the samples taken between 25–50 and 50–75 cm (Figs 2b and 2c) confirm our previous statement, except for a single rendsine, which lies close to vertisols and red soils due to its greater extent of development. The depth between 50–75 cm marks the start of the difference between red soils and vertisols.

The dendrogram obtained for the samples taken at a depth between 75–100 cm reflects clearer differences among the three types of soils. On the one hand, there is a group of vertisols including a well-developed red soil which has not yet attained its accumulation horizon C at such depths; on the other hand, there is a second group consisting of two subgroups: red soils and rendsines. As can be observed, the subgroup of red soils more resembles rendsines than vertisols at these depths, below which they form a calcareous horizon C which ultimately results in the formation of rendsines by the erosive weathering of higher horizons.

Finally, the dendrogram of the samples taken at 100–125 cm does not show strong differences between the different types of soils, which is unmistakably indicative of the fact that this is the depth below which can be found the calcareous substrate, typical in this zone, wherein the difference between the different types of soils is less marked.

Conclusions

Of all the elements analyzed in their assimilable fraction for grapevine cultivation, manganese seems to be the only one which is present in sufficient amounts so as not to result in deficiencies. However, no correction seems to be necessary for copper or zinc, thanks to the continuous use of phytochemicals in one case and to the insignificant response of the cultivation to the elements in the other. Thus, it is iron which shows the greatest tendency to cause chlorotic states in this viticultural region — especially in red soils and rendsines.

The factor analysis carried out on the average profile of the three types of soils investigated provided three different factors, the first of which comprises a large number of variables and establishes differences according to the degree of evolution of the particular soils. The variables with the greatest weight in the second factor are the pH and the iron content, which seems to indicate that this element is the most strongly affected by the pH in its available fraction. The third factor groups % O.M. with available manganese and potassium, which corroborates the relationship between these two variables. The presence of copper in this factor can be ascribed to the continuous use of phytochemicals, which results in its building up in the higher layers.

The dendrograms obtained for the twelve profiles studied reveal that grapevine roots find a similar nutritional medium in red soils and vertisols between 0–50 cm. At depths below 50 cm and above 100 cm, the three types of soils seem to show well-defined differences, although there is a more marked similarity between rendsines and red soils at depths from 75 to 100 cm. Finally, the nutritional medium seems to be independent of the type of soil at depths below 100 cm and to be linked to the calcareous substrate of the Montilla-Moriles region.

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Acta Agronomica Hungarica 37 (3—4), pp. 311—315 (1988)

Animal genetics and breeding

SOME DATA ON TWIN IDENTIFICATION AND PARENTAGE CONTROL USING STUDIES OF BLOOD GROUPS AND BIOCHEMICAL POLYMORPHISM

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(Received 28 March 1986; accepted 18 May 1987)

On the basis of blood group studies carried out by hemolytic test and (zone) electrophoresis for serum transferrin on 15 067 offsprings of 500 Holstein Friesian bulls imported to Hungary, it was found that, of the 124 twin pairs, 99 did not differ from each other in terms of blood groups and transferrin while the other 25 pairs did. These latter differed in serum transferrin types and some of them also in blood group factors. On the other hand, using blood-typing, results for parentage control, have also been obtained.

Among the 15 067 offsprings examined 1732 (11.50%) had faulty results in parentage control. This ratio varies between 2.90 and 28.57% depending on farms or bulls. These results demonstrate that the combination of blood groups and biochemical polymorphisms can well be used for application in animal husbandry.

Keywords: bulls, Holstein Fries, blood group, parentage identification, twin identification

Introduction

Human blood groups have been used in the forensic medicine for many years in order to clarify questions of disputed paternity. *ABO* blood groups were first applied in Austria in 1920 (Wiener, A. S., 1935 cit. Niemann-Sorensen, 1958). Since then this application has been introduced in other countries as well, and several blood group systems discovered later (such as *M*, *N*, *Rh*, etc.) have similarly been used. It is not surprising that the alleles of 13 blood group systems detected in cattle were rapidly applied to solve problems of disputed parentage. After the discovery of the polymorphic character of some serum proteins such as transferrins, albumins, different enzymes, etc. the number of combinations of blood groups and biochemical polymorphisms utilizable in the practice of animal husbandry has further increased.

The application of blood groups and biochemical polymorphic characters in animal husbandry is based on two facts:

(a) Blood group and biochemical polymorphic alleles are transmitted from parents to offsprings according to *Mendelian rules* and form a constant combination (genotype) in an individual throughout life; (b) The existence of the large number of blood group antigens makes the creation of an unlimited number of different genotypes possible.

Thus it is practically impossible to find two individuals with the same genotypes consisting of the same blood group factors and biochemical polymorphic characters, with the exception of monozygote twins (Neiman-Sørensen, 1958; Mitat, 1972; Dohy, 1979; Fésűs, 1984).

The application of blood groups and biochemical polymorphism studies is very wide, such as individual identification, examination of population genetic structure, etc. In the present study we are dealing with two of these: twin identification and parentage control.

Material and methods

Blood group studies were carried out using a hemolytic test and serum transferrin analysis by zone electrophoresis on starch gel in the Immunogenetic Laboratory of Qualification Institute for Animal Breeding and Nutrition (ÁTMI). Five hundred imported Holstein Friesian bulls and their 15 067 offsprings were analysed using reagents belonging to 13 systems of blood groups and on the basis of serum transferrin. These animals are bred on 19 separate farms in Hungary.

Results and discussion

The blood group and serum transferrin factors from 15 067 offsprings of 500 Holstein Friesian bulls were analysed. Among these, 124 twin pairs were found. Of the 124 twin pairs, 99 pairs showed no difference for any of the blood group systems, even for serum transferrin types. Twenty-five pairs differed in their genotypes, all differed in serum transferrin types, and some of them differed in blood group factors. In Table 1, 7 twin pairs of the 25 were presented in order to demonstrate these differences. The first four samples differ only in serum transferrin. The fifth twin pair differs in the *J* and *L* blood group systems. One individual possesses both, the other does not have any. The sixth pair differs in 4 blood group systems i. e. in the *B*, *SU*, *C* and *R'C'* systems. The seventh pair differs in the *J* and *L* system. All of them differ in serum transferrin types. According to genetic theory, monozygote twins always have the same genetic base, thus they must have the same blood group factors and serum transferrin types. Dizygote twins of two kinds exist. One has no common vascular system while the other has.

The former always has some difference in blood group factors and serum transferrin types. In the case of the second type, each individual may have two kinds of red cells. One of them corresponds to its own genotype and the other kind to that of its twin pair. According to Stone and Palme (1952, cit. Mitat,

Table 1

Results of twin identification

Designation of offsprings	Blood group systems													Transferrin
	A	B	C	FV	J	L	M	N	SU	Z	R′S′	N′	T′	
732/9	—	BIO_1QY_2D'	C_2W	FV	—	L	—	—	—	Z	R′S′	—	—	AA
732/9	—	BIO_1QY_2D'	C_2W	FV	—	É	—	—	—	Z	R′S′	—	—	AD_1
159/7	A_2H	$GO_1Y_1A'B'D'E'_2G'Q'Y'$	C_1EW	FV	—	—	—	—	SU_2	Z	S′	—	—	AD_2
159/7	A_2H	$GO_1Y_1A'B'D'E'_2G'Q'Y'$	C_1EW	FV	—	—	—	—	SU_2	Z	S′	—	—	AD_1
833/7	A_2H	$O_xY_2A'E'_3G'I'Q'$	C_1EW	F	J	—	—	—	S	—	S′	—	—	D_1D_2
833/7	A_2H	$O_xY_2A'E'_3G'I'Q'$	C_1EW	F	J	—	—	—	S	—	S′	—	—	D_1E
1021/8	A_2H	$G_1O_xY_2A'E'_2Q'$	C_1EWX_2	FV	J	—	—	—	S	—	S′	—	—	AD_2
1021/8	A_2H	$G_1O_xY_2A'E'_2Q'$	C_1EWX_2	FV	J	—	—	—	S	—	S′	—	—	AA
294/1	—	$BO_1Y_1A'E'_3G'P'Q'$	$GEWX_2$	F	J	L	M	—	S	Z	S′	—	T′	AD_2
294/1	—	$BO_1Y_1A'E'_3G'P'Q'$	$GEWX_2$	F	—	—	M	—	S	Z	S′	—	T′	AA
1541/1	A_2	P_2I'	X_2	F	J	L	—	—	S	Z	R′S′	—	—	AD_2
1541/1	A_2		W	F	J	L	—	—	—	Z	S′	—	—	D_1E
1219/0	—	BO_1B'	WX_2L'	F	J	—	—	—	UU_2	Z	S′	—	—	AD_2
1219/0	—	BO_1B'	WX_2L'	F	—	L	—	—	UU_2	Z	S′	—	—	AA

1972) such an individual may occur which even possesses only 15% red cells corresponding to its own genotype. When this happens the hemolytic reactions obtained may be so weak that they can be easily overlooked and cause wrong conclusions for parentage control. Thanks to blood group and biochemical polymorphism examinations, a number of monozygote twins have been found which were good material for our cattle breeding experiments.

For parentage control, 15 067 offsprings from 500 Holstein Friesian bulls were analysed on 19 different farms. The following results (see Table 2) were

Table 2

Blood groups and serum transferrin in parentage control

Number of bull	Keeping place (country)	Individual design	Correct control		Fault control		Total	
			n	%	n	%	n	%
500			13 335	88.50	1732	11.50	15 067	100.00
	Baranya		758	90.56	79	9.44	837	100.00
	Békés		296	82.91	61	17.09	357	100.00
		4199	67	97.10	2	2.90	69	100.00
		4271	81	96.43	3	3.57	84	100.00
		4033	271	86.86	41	13.40	312	100.00
		4116	83	81.33	19	18.67	102	100.00
	Pest	4461	50	71.43	20	28.57	70	100.00

obtained: Among 15 067 animals examined 1.721 (11.5%) proved to be incorrect for their parentage. This ratio completely corresponds to those reported by most of the authors (Buschman and Krauslich, 1964; Papp, 1972; Bell and Francis, 1970; Kovács, 1973; etc.). It means that in cattle about 10–20% of the offsprings are generally misidentified during parentage control according to blood groups and biochemical polymorphism studies. It can also be seen in Table 2 that this percentage varies between 2, 90 and 28.57% in different farms or for different bulls. It is obvious that the misidentified parentage depends on many factors, such as administration of the herd book, the handling of bull sperm, etc. The causes cannot be completely avoidable, so the detection of errors is very important in the elimination of these individuals from animal breeding.

Conclusion

Blood group and biochemical polymorphism studies help us to identify monozygote twins as being proper material for animal husbandry research; such studies also help identify which offspring has been incorrectly attributed to particular sires and dams during parentage control, in order to eliminate them from animal breeding. The results of this study give further data affirming the importance of examinations of blood groups and biochemical polymorphism in the practice of animal husbandry.

Acknowledgement

We are grateful to G. Csontos, J. Stukovszky and the members of Immunogenetics Laboratory of ÁTMI for the help in the blood groups and serum transferrin analysis.

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Acta Agronomica Hungarica 37 (3—4), pp. 317—321 (1988)

Economics

IMPROVEMENT OF THE ECONOMIC EFFICIENCY BY VALUE ANALYSIS IN AGRICULTURE

(A preliminary publication)

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(Received 3 June 1987; accepted 3 July 1987)

Outlines

The introduction of the method of value analysis in the 40's is due to L. D. Miles, an American engineer. Miles endeavoured to decrease the production costs of industrial commodities. According to his point of view every product must have some function to satisfy human demands. The function includes both useful and showy features, the latter of which help the goods to be marketable.

Using the method of Miles many companies all over the world succeeded in saving an essential amount of money, chiefly by rendering parallel the function elements and the connected costs, and by eliminating superfluous contributions. During the 50's and the 60's the circle of value analysis was widened; it was adapted for the control not only of products but also of technologies, called "value analysis", "value engineering" and "value control". At the same time the method has spread over many countries, particularly the German Federal Republic and in Japa. The economists of socialist countries soon began to adopt this procedure; thus it became implanted among the COMECON countries. Its literature is widespread in many languages.

In Hungary this method was applied at first by the Institute for Postgraduate Training of the Carl Marx University of Economics, by the team of Miklós Lenkey. Later the cause was embraced by the Ministry of Finances, and also by other ministries, among them the Ministry of Agriculture and Food. For the reason of value analysis it could be used at first to some extent in the industrial and trade branches of the economy. In the agricultural production threre was not much opportunity for such a procedure. This fact can be explained with the fundamental formula, which is, generally:

$$\text{value} = \frac{\textit{function}}{\text{costs}}$$

It is clear that the function e.g. of a table or of an airplane must and can be determined already in planning and manufacturing: because the plasticity of an industrial product is — *in thesi* — unlimited. There is a totally different situation as far as an agricultural product is concerned: the features and characteristics of corn or of milk for example cannot be changed, only among certain biological boundary lines.

Domestic experiences

The technical development of the Hungarian agriculture during the 60's made possible the accomplishment of some technological tasks, among more or less determined (industrialized) frames. At the same time the demand to build-up a so-called *food economy system.* in the country showed an upword trend. The management endeavoured to attach the sections of agricultural production and processing techniques to the same system, trying to eliminate the contradictions of special branches. In this situation — at my best knowledge — we tested value analysis primarily also in the agrarian production.

The experiments in the food processing and related industries were quite successful, especially in the tobacco and in the canned goods industries, as well as in the winery, etc; later, during the 70's we came to the very rural, agricultural fields. It is to be understood that there *not the product itself* but the *technology* and the *organization could be analysed* more easily. It is worthwhile to attempt the value analysis of the operation elements of filed and horticultural crops. Relatively good results could be achieved by analysing the technology of vineyard settlements and that of carnation (glasshouse) production, as well as with the rationalization of maize growing technologies. Thereafter more animal husbandry systems (especially pig rearing systems) were analysed, and costs could be decreased essentially.

As it is shown by the yearly national competitions (advertised by the Ministry of Finances), the agricultural branches do not at present fall behind the other fields of economy.

Methods

It cannot be denied that the agrarian economic methods have always some disadvantages in comparison with industrial ones. The backlog is caused by the fact as it is much more difficult to prove their profitability proportion than in cases of manufacturing, where the processes of the products themselves are concerned. The results of agricultural production are very much influenced — beyond the intellectual and manual work — by biological factors and not completely by the climate. It may often happen that the weather will eliminate most of the advantages (or disadvantages) due to the human intervention. This is why one cannot make a true balance on the strength of the results of only a couple of years: a longer period must always be used for base. In the Institute of Economics (University of Horticulture and

Food Industry, Faculty of Production) we tried to assert and enforce this principle. We also tried it when setting up the formula to show the surplus due to value analysis in the production

$$S = 1/t \cdot (b_2 - k_2)n_2 - (b_1 - k_1)n_1 - (i_2 - i_1)$$

where
S = surplus profit, due to value analysis
t = examined period, years
b = returns, Ft
k = costs, Ft
n = product units, natural units, t, piece, hl, etc.
i = investigation sum, Ft
index *1* means: without value analysis procedure
index *2* means: with value analysis procedure

With the help of this formula we can approach the *numerical usefulness* of value analysis. The examinations are continued, because our chief aim is to work out the *methodical details* which can be used by practical farm management.

A new variation

There is a new trend which appears both necessary and promising: to include the value analysis into *healthy food production* and *environmental protection*. For this sake we examine how the value of some products changes, according to the technology; whether it is connected with the increasing use of chemicals or is achieved with more moderate means. Domestic experiments do not give sufficient and adequate data — first because they look back to a short period, and second because most of them were small-scale experiments (organic gardening). During the next years we shall have the opportunity to study the results of the "Natura" Company, which means farming on a 1000 hectare area, without the use of chemicals. These experiments can be precisely evaluated after a certain time. So we shall elaborate the suitable methods, which can be attached to both profitable farming and environmental protection. The greatest problem was how to express, how to disclose the actual savings in favour of one or the other form of production. Nobody can deny that the revealing of natural resources may eliminate considerable expenses of melioration, which become more and more urgent, because of soil pollution.

We are sure that we also can find a great resource by utilizing plant interactions, crop rotations, etc. this is what must be proved with the methods under composition.

Thus we can overcome the difficulties, related to giving numerical sums as the quotient of the value fraction. That is to say, the numerator can be increased by the *surplus price* which is normally paid for the so-called bio-food (food produced with biological methods). This surplus can change between 15 and 50%. At the same time the denominator can be decreased with the proportional part of melioration costs. (These expenses are not incurred at all or are considerably lower in the case of ecological farming, where the acidifying and erosion processes are negligible.)

We must emphasize that among domestic conditions the acidity of soils increased during the last period. The melioration costs change between 3 and 14 thousand Ft/ha, also changing on farm and on national economy level (because of the state support). The decrease of pH is due to many factors (acid rain, industrial and communal pollution etc.), and, last but not least, due to unilateral fertilizing. The area of acid soils in Hungary approaches 2.8 million ha, i.e. about 40% of the total agricultural area. The situation could often be improved by more natural farming methods, with a rational supply of organic matter, supplementing chemicals. In the U.S.A. a new trend, the so-called regenerative farming has already brought some results by reducing costs of fertilizer, shown in Table 1.

Table 1

Experimental results of the University of Nebraska on irrigated corn (1974–77)

Naming	University of Nebraska	Laboratory			
		A	B	C	D
Area I					
Average fertilizer cost, $/ha	71.0	140.9	143.0	174.4	80.0
Corn yield, t/ha	10.73	11.5	10.8	10.6	10.6
Area II					
Average fertilizer cost, $/ha	83.7	183.1	156.6	191.8	103.3
Corn yield, t/ha	11.7	11.5	11.5	11.4	11.6
Area III					
Average fertilizer costs, $/ha	78.2	161.0	130.9	171.3	106.6
Corn yield, t/ha	6.23	9.35	9.0	8.8	9.2

Comments

The laboratories I, II and III gave their fertilizing proposals on the base of the same soil tests, independently from each other. The University tried to save costs without losing proportional yield. We have similar experiments in progress, however, time was too short for adequate conclusions. It would not be authentic to relate to the experiences of one or two years; such short intervals cannot be trusted in agricultural production as to give thorough results. *As far as the method is concerned*, we can apply it very well on the demonstration of connection between function and costs. In worldwide scientific circles the subject is much discussed, whether to endeavour *maximal or optimal yields* of field and garden crops. I am convinced that we can only be competitive and marketable with *rentable production*, with a production in which the production costs are always to be held below the selling price, together with commodity production of quality for solvent and sound demands.

Before achieving this target, many problems remain to be solved and I am perhaps not going too far in stating that the technical development, coordinated by value analysis also may be of some assistance.

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Acta Agronomica Hungarica 37 (3–4), pp. 323–330 (1988)

Reviews

THE APPLICATION OF ELECTROPHORETIC GENETIC EVIDENCE IN THE CHARACTERIZATION AND IDENTIFICATION OF HORTICULTURAL PLANT SPECIES

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The characterization (identification) of cultivars (varieties) is a major concern both to plant breeders and commercial plant growers. Then, owing to the flexibility, the great phenotypic variation and inconsistency of classical morphological as well as physiological traits, plant breeders had to establish correlation between the genotype and phenotype with meticulous, longlasting observations, experiments. This kind of work has however, several pitfalls of its own, e.g.: the misdirected emphasis of certain traits of secondary importance, the mistakes in measurements, the failure to proceed through successive generations, etc. (1). In addition, e.g. if a large number of cultivars of a certain horticultural plant species was introduced into the market, it was difficult to make distinctions among the materials. These all seemed to indicate the lack of more reliable, more objective traits. As urged by this necessity, the development of biochemistry, in the 1950's created a tool — the gel electrophoresis — which seems to have put an end to this problem.

As it is known, enzymes are coded by genes. Consequently, by separating the iso- and/or alloenzymes of differing electric charges on a gel and by a subsequent visualization, an objective biochemical trait can be determined which refers to the genotype of the plant. The discrete bands of zymogram thus resulting relate to gene activity much more directly than do either the morphological or physiological traits. The isozyme pattern is a function of both genetic variability and the degree of electrophoretic resolution (e.g. the application of isoelectic-focusing). The detectability of enzymes can also be affected by the stage of development of the plant, the origin of the plant organ or tissue, etc.

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There have been numerous studies revealing the occurrence of genetically controlled enzyme variants (25, 4, 10, 16), which also proposed their possible applications in plant taxonomy (15, 11).

The principal applications of the method in plant genetics can be summarized as follows:

— study of gene regulation during development
— gene mapping
— study of plant evolution
— detection of somatic variation
— measuring genetic variability in plant populations
— detection and measurement of natural selection, etc.

Despite tremendous progress in the field of application of electrophoretic genetic evidence, we feel that the horticultural applications of this method are not as numerous as it should be. The relatively slow progress in this field can be attributed to several factors. Among them are several problems, e.g.: woody perennials might require special sampling techniques, the secondary metabolites (mainly phenolics) occurring in certain plant species necessitate the development of extraction techniques, etc.

To date several of these obstacles having been overcome, we feel the necessity to review some of the recent horticultural applications of the electrophoretic genetic evidence, making it available, for further research in this field.

Equipment and procedures of electrophoresis

The methods for the electrophoretic separation of active enzymes from plant tissues have been already described in several textbooks and handbooks. A most recent, comprehensive review as well as description is given by Shields, et al. (28), Parfitt and Arulsekar (4). Gels for separating isoenzymes can be made of such different substances as starch, polyacrylamide, agar, etc. For plant identification purposes the starch- and polyacrylamide gels are used more commonly.

Examples of the application of electrophoretic genetic evidence in horticultural crops are given in Table 1.

I. Vegetable crops

— *Lycopersicum* sp. One of the most intensively studied vegetable crops is tomato. Most of the research on this crop was carried out by Rick and coworkers (7), who established a collection of some 800 variants and also char-

Table 1

Enzyme systems applied in the characterization of horticultural species

Species	Enzyme system																					
	Acp	Aat	Adh	Amp	Cat	Est	Enp	Gdh	Got	Gpi	Idh	Lap	Mdh	Me	Pep	Pgd	Pgi	Phm	Prx	Skdh	Tpi	Xdh
Lycopersicum sp.	×		×			×			×		×											
Capsicum annuum					×	×		×	×		×		×			×		×	×	×	×	
Brassica oleracea	×		×						×									×	×	×	×	×
Apium graveolens			×									×				×	×	×				
Cucumis melo						×			×				×			×	×	×		×		
Cucumis sativus						×			×							×	×	×	×			
Cucurbita sp.						×						×					×		×			
Fragaria vesca				×						×		×					×	×				
Malus domestica	×					×							×						×			
Pyrus sp.	×					×													×			
Prunus persica		×	×			×						×	×		×	×				×		
Stone fruits & grape	×		×			×		×		×		×	×			×			×	×	×	
Ornamental plants																						
e.g.: *Petunia* sp.			×					×		×		×	×						×	×		

Abbreviations:

Acp = Acid phosphatase	Aat = Aspartate aminotransferase
Adh = Alcohol dehydrogenase	Amp = Aminopeptidase
Cat = Catalase	Est = Esterase
Gdh = Glutamate dehydrogenase	Got = Glutamate oxalacetic transaminase
Gpi = Glucosephosphate isomerase	Idh = Isocitric dehydrogenase
Lap = Leucine aminopeptidase	Mdh = Malate dehydrogenase
Me = Malate enzyme	Pep = Peptidase P
Pgd = 6-phosphogluconate dehydrogenase	Pgi = Phosphoglucoisomerase
Pgm = Phosphoglucomutase	Prx = Peroxidase
Skdh = Shikimate dehydrogenase	Tpi = Triose phosphate isomerase
Xdh = Xanthine dehydrogenase	

acterized them by isozymic genetic markers. They have also succeded in establishing a close bond between an acid phosphatase locus (Aps-I.) and the gene for resistance to root-knot nematodes (Mi). In principle, 10 enzyme systems can be well applied for the isozyme characterization of tomato (Table 1)

— *Capsicum* sp. The genus is surprisingly less studied for isozymic genetic markers. Nevertheless, making use of the electrophoretic evidence, it has been possible to distinguish three major groups of wild origin within the genus (7, 8) and their domesticated taxa:

Table 2

Taxa	
Wild	Domesticated
(a) Purple flowered group *C. eximum*	*C. pubescence* Ruiz and paven
(b) White flowered group *C. baccatum* group	*C. baccatum* var. *pendulum* (Wild.) Eshbaugh
(c) *C. annuum* group *C. annuum* var. *aviculare* (Dierb.)	*C. annuum* L. var. *annuum*

According to data in the special literature, 17 enzyme systems have been tested in an attempt to characterize the genus. Best results, however, can be expected by using the following: esterase, glutamate dehidrogenase, peroxidase, phosphoglucomutase, glutamate oxaloacetate transaminase, lactate dehidrogenase.

— *Brassica* sp. Electrophoretic evidence had been used for the estimation of the proportion of inbred seeds of *Brassica oleracea* L. as early as 1971. (21). The purity assessment of *B. oleracea* hybrid varieties is routinely done by the major seed companies (31, 32, 34, 6). There are two major reasons for this:

— mechanical harvesting necessitates the uniformity of the crop

— the self-incompatibility system of this species does not always provide an efficient protection against self or sib pollination between plants of the female inbred, resulting in non-hybrid seeds.

— *Apium* sp. The study of the inheritance of electrophoretic variability in the species *Apium graveolens* L. started in 1979. Since then, nine isozyme loci have been identified and six of them have already been mapped (22).

— *Cucurbitaceae.* The Family *Cucurbitaceae* comprises horticulturally important species, several of which have been subject to isozyme study.

— *Cucumis* sp. On the basis of an extended study of wild and cultivated *C. melo* populations it has been possible to conclude that India rather than Africa should be regarded as the centre of diversity in this species (12, 13). Similar studies were made with cucumber *Cucumis sativus* (14), too, revealing

2 morphologically distinct forms, *C. anguria* var. *anguria* and var. *longipes* among the wild *Cucumis* species (25). Isozyme traits have similarly been useful in the study of inter- and intraspecific variations within the genus *Cucurbita*, too (20, 21). The specific isoenzyme patterns (mainly that of the esterase) have proved to be suitable for the identification, separation of species, varieties (22).

II. Medicinal and spice plants

To date there is almost no report on the applications of electrophoretic genetic markers in this special field of plants. The lack of such studies is all the more worth mentioning, as the exact knowledge of the genetic basis should be one of the preconditions for studying the taxonomy, chemismus of these species. In our opinion, the application of the electrophoretic genetic evidence in these crops would greatly contribute to increase the efficiency of research in this field.

The content of special secondary metabolites present in these species would expectedly require special extraction methods, etc. However on the basis of our preliminary experiments with species of the *Eleagnaceae*, *Labiatae*, *Solanaceae* and *Umbelliferae* families, substantial characteristical regularities revealing also certain individual variations could be detected in the Est, Lap and Pgm enzyme systems.

III. Fruit crops

— *Fragaria* sp. Strawberry *(F. vescad* is one of the fruit species in which the application of isoenzyme genetic markers has been most relevant. This fingerprinting method has been applied both for measuring genetic variations and the inheritance patterns in polyploids (1). The Gpi isozyme variability in the cultivars has also led to the deduction (supports the theory) that cultivated strawberry arose by the natural hybridization of F. *virginiana* and *F. chiloensis* (10). Gpi, Lap and Phg enzyme systems have also been useful in characterizing 22 of the presently or formerly important California cultivars of strawberry (29).

— *Malus* sp. Peroxidase isoenzymes from shoot bark tissues have been successfully applied in apple (*Malus pumilla* Mill.) scion cultivar identification. The isozyme patterns were consistent for cultivar, independent of season, age or eco-physiological condition of the plants, permitting cultivar identification. The isozyme patterns were consistent for cultivar, independent of season, age or eco-physiological condition of the plants, permitting cultivar identification already in the juvenile phase of growth (19, 20).

— *Pyrus* sp. In an isozyme study on the characterization of 37 selected *Pyrus* species and cultivars — accession of the Nat. Clonal Germplasm Repository, Cornvallis — all species tested were distinguishable (5).

— *Prunus* sp. Among the important temperate zone fruits of the genus *Prunus*, peach (*Pr. persica* L Batsch) is perhaps the best characterized species in terms of genetics. Nevertheless, in a study of malate-dehydrogenase isoenzymes of 290 peach cultivars, additional information could be obtained on the genetic behaviour both of Mdh isozyme phenotypes and on haploids (23). Similarly, two enzyme systems (Gpi, Pgm) have been successfully applied in the identification of plum$\times$peach hybrids (3).

— Other fruit species (cherry, plum, almond, walnut) are relatively difficult to analyse by this method, since phenolic compounds present in them cause several difficulties. Nonetheless in a recent study Arulsekar and Parfitt (26) report on modified extraction methods and the successful characterization of these species by 13 enzyme systems. The same enzyme-systems were also efficient in the study of *Vitis* sp. It should, however, be mentioned that grape species were effectively identified by Wolfe (33) as early as 1976).

IV. Ornamental plants

It cannot be the purpose of this review to survery the vast diversity of ornamental plants in view of isozyme application, therefore, in the following only a few examples are given indicating the applicability of electrophoretic genetic evidence in their characterization: *Petunia* sp. (8), *Rose* sp. (17), *Poinsettia* sp. (16), *Liriodendron* sp. (30), *Phlox* sp. (19), turfgrass (35), etc.

Conclusions

Electrophoretic genetic evidence as a tool for horticultural crop research, offers several immediate advantages. Thus, in breeding it can be applied in

— the identification of natural and parasexual hybrids,
— the study of pollen gene expression and selection,
— the study of introgressions from wild species,
— the breeding of cross-pollinated crops,
— plant disease resistance research, etc.

Further applications seem to be relevant also in

— the characterization of the genetic materials in germplasm repositories, nursery collections,
— monitoring the genetic variability of both natural and cultivated populations (also their comparison).

— the estimation of fertility in the course of the breeding process, providing also information on the mating system of species,
— the estimation of F_1-seed purity,
— providing additional information to answer byosystematic questions
— the characterization of varieties (cultivars), the establishment of varietal distinctness — also in view of the protection of breeders' rights,
— the estimation of somaclonal variation in tissue cultures, etc.

Without overestimating the present and possible perspective role of electrophoretic genetic evidence in horticulture, it can be stated that it provides a relatively stable and comparatively less expensive routine method for establishing the genetic nature of species, and cultivars. Consequently, it is a method worth employing more frequently.

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Acta Agronomica Hungarica 37 (3–4), pp. 331–336 (1988)

USE OF MICRO-IRRIGATION ON GREENHOUSE CROPS

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(Received 27 June 1986; accepted 19 August 1986)

Greenhouse cultivation enables us to obtain early and very valuable produce, but it is necessary for the producer to supply all the water needed by the crops.

At the beginning, the most widespread system was the furrow irrigation, which was later superseded by sprinkler irrigation. However, drip irrigation is at present considered preferable, being suitable for both flower and food production.

Among the various types of drip irrigation, the linear distribution systems have been particularly well developed. They are suitable for the crops planted in rows and can be arranged in such a way as to be easily assembled and disassembled at any change of crop, even three or four times a year.

As far as flower cultivation is concerned, sprinkler and spray irrigation systems are still the most generally used; sometimes pot-localized irrigation is also practised.

Sub-irrigation systems have now started to be employed in horticultural areas with sandy soils.

The peculiar character of greenhouse cultivation is suitable for the purpose of forcing the vegetative cycle to obtain early, very valuable produce, which then can be sold at a higher price than that from field production.

Another specific character of the greenhouse cultivation is the fact that natural rains are prevented by the roof from reaching the soil and therefore all water requirements of the plants must be artificially supplied.

The greenhouse cultivation can be divided into two main classes: permanent crops and temporary crops. The permanent crops are generally tropical flower plants that in our climate must always live in a protected environment (i.e.: orchids).

The temporary crops (horticultural or floricultural) are forced crops that complete their vegetative cycle in a few months, so that three or four crops per year are effected on the same ground, thus causing particular problems with the assembling and disassembling of the irrigation system.

Until a few years ago the most common irrigation system was the sprinkler. In the last ten years, however, the localized irrigation system has come to be employed in several different ways, sometimes in association with the sprinkling system which in this case has the prevailing character of climate conditioning in order to cool and humidity the air.

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It is very difficult to make a clear distinction between sprinkling and micro-jet localized irrigation, because the difference is represented by the dimension of the sprinklers that are always rather small in greenhouses anyhow.

During recent years a development of underground irrigation in greenhouses or orchards has been noticed but the enthusiasm has declined on account of the failures that occurred in some areas of Southern Italy and the Italian islands.

Probably the determining factor in these failures is represented by the physical characteristics of the soil.

Only in sandy soils does the high permeability allow the adoption of continuous watering systems with a capillary hose; while in soils with clayey components, it is necessary to supply larger supplies of water in a more discontinuous way.

At present, the sub-irrigation is mainly a hope.

Sprinkler irrigation, taking into account the types of sprinklers, can be generally classified as follows:

$$\text{Sprinkler}\left\{\begin{array}{ll}\text{Static} & \left\{\begin{array}{l}\text{mist spray}\\ \text{head}\end{array}\right.\\[2ex] \text{Rotating} & \left\{\begin{array}{ll}\text{vertical-sprinklers} & \left\{\begin{array}{l}\text{full circle}\\ \text{by sector}\end{array}\right.\\ \text{minisprinkler} & \left\{\begin{array}{l}\text{free (spinners)}\\ \text{controlled (intermittent)}\end{array}\right.\end{array}\right.\end{array}\right.$$

The following basic differences exist between static and rotating sprinklers:

Static sprinklers

Static sprinklers are simple, strong and cheap. They can cover a very limited area with a high hourly rain intensity. Some types are used for foot irrigation of crops (such as carnations) which suffer if watered on the leaves.

Rotating sprinklers

Some of these consist of small real rotating sprinklers operating upside-down (Rain Bird 20, Naan 213/98) or vertically (Kombi 234 full circle, Kombi 233 part circle). Minisprinklers are also much used: they consist of small rotating sprinklers which can cover a large area with a low rain intensity; so that a greenhouse needs a limited number of sprinklers and each sprinkler requires little operation.

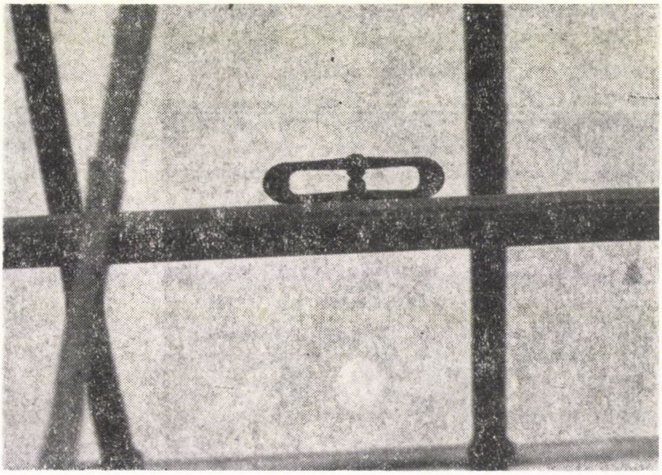

Fig. 1. Irrigation based on the static spray head is much in use for both horticulture and floriculture. In Sicily this system is often added to a linear one; the latter with the purpose of localized irrigation, and the former with the purpose of air moistening

Generally they have a range radius of 6–8 m and they can by used on crops that require leaf wetting.

Localized irrigation

At present, localized irrigation is widely adopted for its versatility.

It can be divided into the following three main groups.

— linear
— localized by pot
— subirrigation.

Linear systems are represented by a watering pipe provided with holes which supplies a small water flow, so that in this way it is possible to water a long (up to 50 m) and narrow (0.3–0.5 m) area.

Several devices have been applied to improve the irrigation uniformity in regard to length.

From the simplest type (a large diameter pipe with many little holes) this system ranges to several kinds of double pipe (Biwall, Twinwall,) to special pipes which have, on their welding different emitters (labyrinthic, capillary, etc.).

In Italy, besides the national production kinds (Rimoldi, Geco, IR-Drop, etc.) almost ten imported kinds are available but, as only a few present adequate characteristics, are no more requested.

Linear systems are generally used in orchard crops with a short cycle so that a great ease of assembling and disassembling is strictly required.

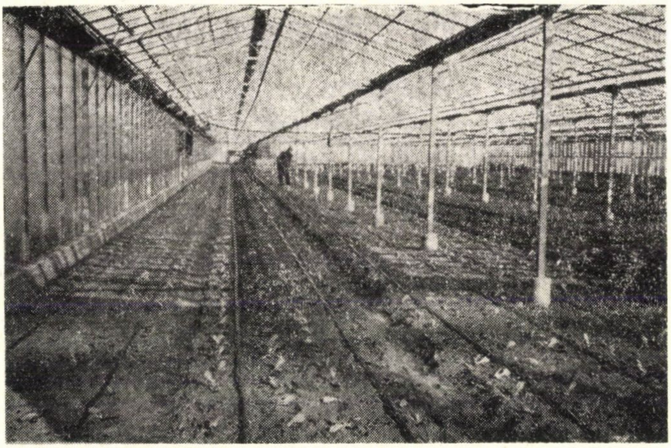

Fig. 2. This is the system of linear localized irrigation (twin-wall) in use for horticulture, which has superseded the former furrow irrigation with a saving of labor and water

Pot localized system

Systems of localized irrigation with capillary emitters are used for pot flower cultivation. The first system of this kind was the Danish Vollmatic, still widely used in Liguria.

A remarkable improvement in the application uniformity is obtained by using multi-exit emitters to which are applied adequate capillary pipes (spaghetti).

Fig. 3. The system of localized irrigation is used for pot cultivation of flowers; and is similar to the Volmatic system, though built from scratch by the farmer, employing microtubes

Fig. 4. The capillar sub-irrigation system (Viaflo) for hotriculture has performed very well on sandy sails

The problems

In the specific case of greenhouse localized irrigation, some difficulties have arisen, and we would like to mention them here in hope of beginning a fruitful exchange of information. Filtration problems are no longer remarkable news. On the contrary, two difficulties seem particularly important: first, there are the obstructions resulting from calcareous (and iron-salt) waters. The method of effectuating periodical washings with hydrochloric acid at 5% has not produced very good results. In Southern Italy nitric acid at 1%, has

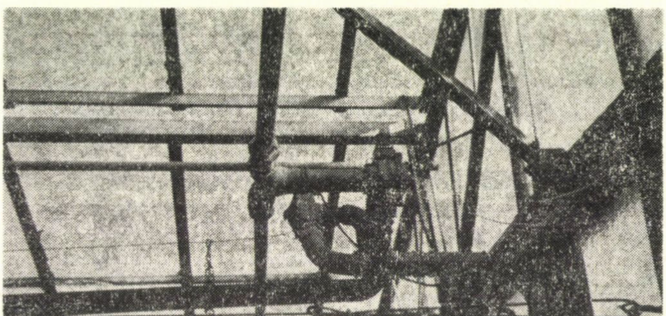

Fig. 5. Detail of two electro valves for the automatic controls of a plot irrigated by sprinklers

also been used, but this is d angerous and costly. Citric acid was also used with poor results. The question arises wheather it is convenient to effectuate water treatment at source.

The second problem concerns fertilizing, which in some cases can contribute to the formation of precipitates.

The general problem is, after all, the study of a highly automatized system in order to reduce work, to realize a more rational water exploitation and to improve humidity sensorials. In this respect, we deem that the most efficient is the tensiostat, which operates well only on sandy soils; while in the presence of clayey soils it presents some difficulties.

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Acta Agronomica Hungarica 37 (3—4), pp. 337—351 (1988)

NATURE AND ESTIMATION OF GENETIC COMPONENTS OF VARIATION

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(Received: 13 March 1986 accepted 19 December 1986)

A summary of the nature of genetic variation and its estimation is presented. Estimation of genetic parameters using diallel approach and combining ability is described. Relationship between variance due to combining ability and components of genetic variances from diallel analysis is also presented.

Keywords: genotypic variation, and its estimation of genetic parameters, diallel analysis

Nature of genotypic variation

A detailed knowledge about the magnitude and nature of genetic variation in a specific population is of prime importance for the effective prediction of genetic improvement and for choosing the most efficient selection scheme in a breeding programme. The inheritance study of quantitative characters in plants began with the works of Johannsen (1909), Nilsson-Ehle (1909) and East (1916). The theoretical basis of quantitative genetics was laid down by Fischer (1918), Wright (1921) and Haldane (1932). Fisher (1918) divided the genotypic variance into three logical components: (a) due to additive effects of genes (additive genetic variance), (b) due to dominance deviation from the additive scheme, arising from the intra-allelic interaction of genes (dominance variance) and (c) due to non-allelic interaction of genes (epistatic variance). Fisher et al. (1932) promoted an experimental approach for estimating and separating additive and dominance variances using second and third degree statistics. Wright (1935) defined and gave detailed treatment to this division of genotypic variance. Epistatic variance was further partitioned into factorial components of the digenic and higher order of interactions, such as additive $\times$ $\times$ additive, additive $\times$ dominance, dominance $\times$ dominance for two loci situation, and additive $\times$ additive $\times$ additive, etc. for three or more loci, by Cockerham (1954) and Kempthorne (1955).

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Extensive study in biometrical genetics started soon after the work of Lush (1940, 1943, 1945), Sprague and Tatum (1942), Comstock and Robinson (1948) and Mather (1949). The following three parameters were described by Dickerson (1963), Gardner (1963), Dudley and Moll (1969) and Mather and Junks (1971) in respect of genetic variance:

(a) *Additive genetic variance* with results from the additive effects of the genes at all segregating loci. For a single locus, it is determined by the gene frequency and by the average effect of substituting one allele for the other (additive effects). The difference between two homozygotes is the additive genetic effect. Additive genetic variance is a fixable variance.

(b) *Dominance variance* which results from intraallelic interaction of genes at segregating loci. This is an unfixable component of genetic variation.

(c) *Epistatic variance* which results from the inter-allelic interaction of genes at two or more segregating loci. It was partitioned into additive × additive, additive × dominance and dominance × dominance component for two segregating loci, and into additive × additive × additive, etc. for three or more loci. Among the epistatic variances, only the interactions arising from additive effects i.e. additive × additive, additive × additive × additive, etc. are fixable and can be utilized for intrapopulation improvement programmes. Other types of epistatic variances e.g. additive × dominance, dominance × dominance, etc. are non-fixable and can be exploited in hybrid programmes only.

Gardner (1963) included three more parameters:

(a) *Average degree of dominance* or ratio of dominance variance to additive genetic variance (dominance ratio) which describes the relative importance of additive and non-additive genetic variances.

(b) *Genotype × environment interaction* which may again be divided into additive gene effects × environment and non-additive gene effects × environment.

(c) *Genotypic correlations* among various quantitative characters of importance to the particular crop.

All these genetic parameters have been estimated following various procedures. These are outlined in the following section.

Methods for estimating the genetic parameters for metric characters

A number of procedures have been developed for the estimation of genetic parameters which differ in basic genetic assumptions and the nature of material used. The common assumptions imposed for these methods are:

(a) normal diploid segregation,
(b) no differences between reciprocal crosses,

(c) no multiple allelism,
(d) linkage equilibrium,
(e) random selection of plants and
(f) no epistasis.

The last assumption, i.e. no epistasis, was imposed to simplify the methodology in the estimation of genetic components (Comstock and Robinson, 1948; Jinks and Hayman, 1953; Hayman, 1954b; Allard, 1956a).The non-allelic interaction component can, however, be detected by a proper scaling test (Mather, 1949) or by using more refined techniques utilizing first or second degree statistics (Hayman and Mather, 1955; Anderson and Kempthorne, 1954; Hayman, 1957, 1958b; Junks and Jones, 1958; Coughtrey and Mather, 1970).

Two types of genetic parameters have mainly been used to study the genetic architecture. These are:

(a) Means which are partitioned to provide the estimates of genetic effects through the first degree statistics.
(b) Variance and covariance which are partitioned to provide the estimates of genetic variances through the second degree statistics.

The second order statistical measures being functions of squares are always positive and therefore, more useful than first degree statistics (Cockerham, 1961; Mather and Junks, 1971).

The following methods have been used for the estimation of genetic parameters:

(1) *Studies of gene action:*

(a) Studies on gene effects based upon means of segregating generations as followed by Anderson and Kempthorne (1954), Hayman and Mather (1955), Hayman (1958b), Horner et al. (1961), Gamble (1962) and Sprague et al. (1962).
(b) Studies on components of genetic variance:
   (i) Segregating generations: Estimates based upon segregating generations from crosses of two pure lines (Mather, 1949).
   (ii) Diallel analysis.
(1) Numerical analysis:
   a. For homozygous parents (Jinks and Hayman, 1953; Jinks, 1954, 1956; Hayman, 1954a, 1954b, 1958a).
   b. For heterozygous parents (Dickinson and Jinks 1956).
(2) Graphical approach (Wr, Vr and Wr, W' graphs):
   a. For homozygous parents and Jinks Hayman, 1953; Hayman, 1954b; Jinks, 1954; Allard, 1956a, 1956b).
   b. For heterozygous parents (Dickinson and Jinks, 1956).

(iii) Covariances between relatives: Covariances between half-sibs and full-sibs in relation to additive, dominance and other genetic variances (Comstock and Robinson, 1948, 1952).

(c) Triallel and quadriallel analyses (Rowlings and Cockerham, 1962a, 1962b).

(d) Powers' partition method (Powers, 1951, 1955, 1963).

(2) *Studies on combining ability:*

(a) Diallel analysis:

(i) For homozygous parents (Sprague and Tatum, 1942; Rojas and Sprague, 1952; Henderson, 1952; Griffing, 1956a, 1956b).

(ii) For heterozygous parents (Matzinger and Kempthorne, 1956; Matzinger et al. 1959; Lonnquist and Gardner, 1961; Gardner and Eberhart, 1966).

(iii) Covariance between relatives: Covariance between half-sibs and full-sibs in relation to general and specific combining ability variances (Kempthorne, 1957).

(b) Partial diallel approach (Kempthorne and Curnow, 1961; Fyfe and Gilbert, 1963).

(c) Line×tester analysis (Kempthorne, 1957).

(d) Top cross test (Davis, 1927; Jenkins and Brunson, 1932).

(e) Polycross test (Tysdal et al., 1942).

(f) Open-pollinated progeny test (Allard, 1960).

Among the above mentioned methods, those that have been used most often are the diallel crosses and in the following sections they are described in some detail.

Estimation of genetic parameters using diallel approach

The diallel crossing system was first introduced by Schmidt (1919), in which each of a group of males was crossed with each of a group of females. Hayman (1954b) defined diallel cross as "the set of all possible matings between several genotypes". The diallel cross was first analysed by a statistical technique by Sprague and Tatum (1942). Griffing (1956b) elaborated the method of estimation of general combining ability (g.c.a.) and specific combining ability (s.c.a.) using four methods and two models of calculations.

Hull (1946) and Jinks and Hayman (1953) developed the methods for analysis of genetic components of variance from diallel crosses. The methodology of Jinks and Hayman (1953) which utilized Mather's (1949) components of variation D and H, has been further elaborated by Hayman (1954a, 1954b, 1957, 1958a, 1960) Jinks (1954, 1955, 1956), and Allard (1956a, 1956b).

The basic assumptions on which diallel theory is based (Jinks and Hayman, 1953; Hayman, 1954b; Jinks, 1954; Allard, 1956a) are:

(a) Diploid segregation.
(b) No differences between reciprocal crosses.
(c) Independent action of non-allelic genes.
(d) No multiple allelism
(e) Homozygous parents.
(f) Genes independently distributed between the parents.

The basic assumptions are to be fulfilled before estimating the parameters (Hayman, 1954b). The fulfilment of these assumptions can be decided through various tests (Mather and Jinks, 1971).

Various authors have discussed the effect of a failure of these assumptions (Jinks and Hayman, 1953; Hayman, 1954b; Jinks, 1954; Allard, 1956a; Dickinson and Jinks, 1956). Kempthorne (1956) gave a general approach to the genetical theory and analysis of a diallel table where the assumptions of two alleles at each locus and no epistasis were removed. Dickinson and Jinks (1956) extended the diallel analysis to heterozygous parents. The diallel analysis was extended to cover autotetraploids by Dessureaux (1959). The analysis proposed by Hayman (1954a) was modified by Jones (1965) thus enabling its application when reciprocal crosses are not produced. Durrant (1965) extended the analysis of Hayman (1954b) and Jinks (1954) to determine the reciprocal differences. Nassar (1965) investigated the magnitude of effect of gene correlation arising from the random sampling of parental genotypes. Formulae to estimate the gene frequencies and dominance ratio for random mating population were provided by Oakes (1967).

There are two approaches in the diallel analysis for the study of gene effects: (a) graphical and (b) numerical for the estimation of genetic parameters.

(a) Graphical analysis

Jinks and Hayman (1953) developed the graphical approach for diallel analysis for homozygous parents based on Mather's (1949) components of variation, using second degree statistics; i.e. Vr (variance of all offsprings of each parent), Wr (the covariance of offsprings in each parental array with nonrecurring parents) and Vp (variance of parental values). They pointed out the importance of a slope of regression line (Wr on Vrd and its position in relation to the limiting parabole ($Wr^2 = Vr \cdot Vp$). The regression of Wr on Vr provide a graphical representation of the degree of dominance and also permits the separation of true dominance from the spurious "dominance" caused by many types of non-allelic interactions. The array points are inside the limiting parabola. The slope of regression line is independent of the degree of dominance, but its position would shift from the point of origin depending upon the level of dominance. It intersects the *Wr* axis at the origin with complete dominance, on the positive side with partial dominance and on the negative side with overdominance. The distribution of array points in the (*Vr*, *Wr*) graph also suggests the order of dominance of the parents. The array points with low *Wr* and *Vr* values (i.e. close to the origin) have a maximum number of dominant alleles. They also discussed the possibility of prediction of the value of completely dominant and most recessive parents, in case there is strong correlation between the parental order of dominance ($Wr + Vr$) and the parental measurement (*yr*).

The effect of failure of assumptions as envisaged by Jinks and Hayman (1953); Jinks (1954) and Hayman (1954b) showed that the average degree of dominance may be increased or decreased by the lack of independent genes in the parents. A serious overestimation of the degree of dominance will occur in the case where the dominance of all loci is in the direction of the favourable (plus) alleles and where the correlation between gene frequencies at different loci is due primarily to dispersion (Hayman, 1954b; Coughtrey and Mather, 1970). Baker (1978) critically reviewed the literature on the effects of failing to fulfil various assumptions and concluded that some of the assumptions might be violated with impunity; while others, such as no epistasis and non-correlated distribution of genes among the parents, need careful analysis.

Jinks (1954) and Hayman (1954b) elaborated the effects of genetic interaction on the slope of regression line (*Wr*, *Vr*) and suggested omitting the interacting arrays before further analysis. They also studied the effects of linkage and different types of epistasis on (*Vr*, *Wr*) graph. Allard (1956a, 1956b) applied the statistics *W*' (covariance between array means and the offspring in each array), in (*Wr*, *W*') graph. He suggested the use of both (*Vr*, *Wr*) and (*Wr*, *W*') graphs in order to obtain a better understanding of the nature of gene action. In the (*Wr*, *W*') graph the degree of dominance influence the scatter of array points and has no effect on slope or the position of the line. All the parents involved in the study occupy a single position when dominance is absent. With the increase of dominance, the spread of the points along the line is increased, when the most recessive parent occupies the position in the first quadrant farthest removed from the origin. A complementary type of interaction causes some points to fall below the line of unit slope on the (*Vr*, *Wr*) graph and has the opposite effect on the (*Wr*, *W*') graph. Johnson and Aksel (1959) presented a method for standardized deviation graph drawn with the value for parental parameters (*yr*) and order of dominance ($Wr + Vr$) so as to determine whether dominance was due to positive or negative gene effects.

(b) Numerical approach

Link and Hayman (1953) proposed the numerical approach to estimate genetic parameters based on Mather's (1949) notation. They defined four components, viz. D, H_1, H_2 and F, assuming additivity and dominance but no epistasis. The component D measures additive variance while H_1 and H_2 measure dominance variance. The component H_1 has the same coefficient as D so that the square root of the ratio H_1/D measures the degree of dominance. F indicates whether dominant or recessive alleles are more frequent in the parents, being positive if dominant alleles are in excess. The ratio $H_2/4H_1$ indicates the symmetry of positive and negative allels exhibiting dominance. Hayman (1954b) presented in detail the theory and algebraic basis of analysis and added two more statistics, h^2 and Fr to those suggested by Jinks and Hayman (1953). The dominance effect (as the algebraic sum over all loci in heterozygous phase in all crosses) was presented by h^2, and covariance of additive and dominance effects in a single array was presented by Fr Jinks (1956) extended the applicability of diallel analysis to F_2 and backcross generations derived from a set of F_1 diallel crosses. The coefficient of 'h' is half in F_2 generation as concluded by Jinks (1956), other statistics being the same as that for F_1 diallel analysis. Diallel analysis using F_2 generation was also provided by Hayman (1958a) where he described the estimations of D, H_1, H_2 and F. Hayman (1957) after detailed study concluded that the degree of dominance, $(H_1/D)^{1/2}$ estimation is not seriously disturbed for multiple allelism and gene correlations in the parents. The methodology of Jinks (1954) and Hayman (1954b) was extended by Hayman (1960) for fixed or specified lines, which represented samples of a specific population and also correlated his various genetic parameters with Griffing's (1956a, 1956b, 1958) combining ability analysis.

Jinks and Stevens (1959) presented the joint analysis of parents, F_1, F_2 and backcross generations of a diallel set of crosses as an alternative approach to the problem of estimating the components of variation to that followed by Jinks (1956). They estimated the components D, H_1, H_2, I, J, L_1 and L_2.

Diallel analysis was extended for heterozygous parents by Dickinson and Jinks (1956) where they estimated the parameters D_{I}, D_{II}, H_{I}, H_{II}, H_{III}, H_{IV}, F_{I}, F_{II} and 3. In the presence of heterozygosity in the parents, the approach of Jinks and Hayman (1953) is based in the estimation of D, H_1 and H_2. As a result, the degree of dominance would be underestimated, the proportion of dominants would be overestimated while the asymmetry of gene distribution would also be exaggerated. When D is estimated from homozygous parents, it contains a small contribution of 'h' (deviation of heterozygote from the mean of homozygote), and in the heterozygous scheme it is represented by H_{II}, H_{III}, F_{I} and F_{II}. Four parameters, H_{I}, H_{II}, H_{III} and H_{IV}, are related and dependent on the frequency of homozygotes and heterozygotes. These parameters are reduced to those of Mather (1949) namely, D, H and F under random mating. The parameters H_{III}, H_{IV} and F_{II} become zero and the model is reduced to that of Hayman (1954b) and Jinks (1954) with completely homozygous parents.

Combining ability

(a) Concept of combining ability

The term combining ability was introduced by Sprague and Tatum (1942) where they used general combining ability (g.c.a.) to designate "the average performance of a line in hybrid combinations" and specific combining ability (s.c.a.) as "those crosses in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines involved". Among animal breeders the term "nicking" has been used in the same general sense. By g.c.a., Henderson (1952) meant "the average merit with respect to some trait or weighted combination of traits of an indefinitely large number of progeny of an individual or line when mated with a random sample from some specified population under a specified set of environmental circumstances". The specific combining ability was defined by him as "the deviation of the average of an indefinitely large number of progeny of two individuals or lines from the value which would be expected on the basis of the known general combining abilities of those two lines or individuals as the maternal ability of the female parent".

Griffing (1956a, 1956b, 1958) presented the statistical concept of the general and specific combining ability in both the homozygous and heterozygous base populations. Griffing (1956b) outlined the procedure for the estimation of general and specific combining ability effects and variances from diallel crosses. Based on the materials included in the diallel cross experiment, he considered the following four methods:

Method 1: Parents, one set of F_1's and reciprocal F_1's are included (all p^2 combinations where p is the number of parents).

Method 2: Parents and one set of F_1's are included (no reciprocals)

$$1/2p(p+1) \text{ combinations}$$

Method 3: One set of F_1's and reciprocals are included but not the parents

$$p(p-1) \text{ combinations}$$

Method 4: One set of F_1s but neither parents nor reciprocal F_1's is included

$$1/2p(p-1) \text{ combinations}$$

For the last two cases where parents are not included, he used the term "modified diallels". He provided two models for each of the four methods:

(a) Model I (fixed effect model) where the parental materials are selected and the results obtained are applicable to the material investigated. Here the main interest lies in the estimation of combining ability effects.

(b) Model II (random effect model) where the parents are random samples from the population about which the inference are to be drawn. Here interests like in the estimation of the genetic and environmental components of the population variance.

The analysis of variance is very similar in both models, but the parameters tested in them are very different. In most cases, the fixed effect model is used by the plant breeders since they are generally interested in the genetic information about a particular set of parents. However, if the parents are chosen by random sampling of some large population, there is no fault if they are analysed by the fixed effect model. On the other hand, it is questionable to utilize a random effect model for the analysis of data requiring a fixed effect model (Baker, 1978).

A model for the analysis of diallel cross involving open-pollinated varieties and synthetics in Hardy-Weinberg (1966) and Eberhart and Gardner (1966). They partitioned the genotypic variance into that due to parents and that due to heterosis. The former was again split for homozygous and heterozygous loci and the latter was split into average heterosis, variety heterosis and specific heterosis. They considered three situations, viz.:

(a) Analysis I: which induced variety selfed, variety cross and variety cross selfed.

(b) Analysis II: when only varieties and their crosses were included.

(c) Analysis III: when only varietal hybrids were included.

Analysis II and Analysis III are similar to that of Griffing's (1956b) methods 1 and 2, respectively.

(b) Relationship between variance due to combining ability and components of genetic variances

In a diallel experiment, three are two types of relatives: half-sibs, which are individuals with one parent common; and full-sibs, which are individuals with both parents common.

The relationships between covariance of relatives and variance of genetic components as given by Matzinger and Kempthorne (1956), Kempthorne

(1957) and Kempthorne and Curnow (1961) are as follows:

$$\text{Cov. (H. S.)} = \sigma_g^2 = \left(\frac{1+F}{4}\right)\sigma_A^2 + \left(\frac{1+F}{4}\right)^2 \sigma_{AA}^2 + \left(\frac{1+F}{4}\right)\sigma_{AAA}^2 + \ldots$$

$$\text{Cov. (F. S.)} = 2\sigma_g^2 + \sigma_s^2 = \left(\frac{1+F}{2}\right)\sigma_A^2 + \left(\frac{1+F}{2}\right)^2 \sigma_D^2 + \left(\frac{1+F}{2}\right)^2 \sigma_{AA}^2 +$$

$$+ \left(\frac{1+F}{2}\right)^3 \sigma_{AD}^2 + \left(\frac{1+F}{2}\right)^4 \sigma_{DD}^2 + \ldots$$

where,

Cov. (H. S.) = covariance of half-sibs,
Cov. (F. S.) = covariance of full-sibs,
σ_s^2 = variance due to g.c.a.,
σ_g^2 = variance due to s.c.a.,
σ_A^2 = additive genetic variance,
σ_D^2 = dominance variance,
σ_{AD}^2 = additive $\times$ dominance interaction,
σ_{AA}^2 = additive $\times$ additive interaction,
σ_{DD}^2 = dominance $\times$ dominance interaction,
and F = inbreeding coefficient.

Griffing (1956a) observed the following relationships for inbred lines ($F = 1$):

$$2\sigma_{g.c.a.}^2 = \sigma_A^2 + 1/2\sigma_{AA}^2 + 1/4\sigma_{AAA}^2 + \ldots$$

$$\sigma_{s.c.a.}^2 = \sigma_D^2 + 1/2\sigma_{AA}^2 + \sigma_{AD}^2 + \sigma_{DD}^2 + 3/4\sigma_{AAA}^2 + \sigma_{AAD}^2 + \sigma_{ADD}^2 + \sigma_{DDD}^2 + \ldots$$

$$\sigma_G^2 = 2\sigma_{GCA}^2 + \sigma_{SCA}^2 = \sigma_A^2 + \sigma_D^2 + \sigma_{AA}^2 + \sigma_{AD}^2 + \sigma_{DD}^2 + \sigma_{AAD}^2 + \sigma_{ADD}^2 +$$

$$+ \sigma_{DDD}^2 + \ldots$$

where, σ_G^2 = total genotypic variance,

σ_{GCA}^2 = variance due to g.c.a.,

and σ_{SCA}^2 = variance due to s.c.a.

It may be noted that $\sigma_{g.c.a}^2$ is also the covariance between parents and offspring in a random mating population at equilibrium. Similar estimates were also obtained by Matzinger (1963) for combining ability when gene frequencies are equal. From the above relationships, it is apparent that the g.c.a. variance contains an additive variance and a part of epistatic component involving additive $\times$ additive, additive $\times$ additive $\times$ additive, etc. Specific combining ability variance on the other hand contains dominance variance and a major part of the epistatic component involving both additive and non-additive components.

In the absence of epistasis, the above equations are reduced to:

$$2\sigma_g^2 = \sigma_A^2 \text{ and } \sigma_s^2 = \sigma_D^2 \,.$$

The relationship to Mather's (1949) components as given by Hayman (1960) are:

$$4\sigma_g^2 = D_R \text{ and } 4\sigma_s^2 = H_R$$

(in original random mating population from which inbred lines were derived). When $F = 0$ (the lines are not inbred) then

$$\sigma_g^2 = 1/4\sigma_A^2 + 1/16\sigma_{AA}^2 + \ldots, \text{ and}$$

$$\sigma_s^2 = 1/4\sigma_D^2 + 1/8\sigma_{AA}^2 + 1/8\sigma_{AD}^2 + 1/16\sigma_{DD}^2 + \ldots$$

By ignoring the epistasis, $\sigma_g^2 = 1/4\sigma_A^2$ and $\sigma_s^2 = 1/4\sigma_D^2$

Pooni et al. (1984) compared the relationship between the estimates of general (σ_g^2) and specific (σ_s^2) combining abilities from the four methods of diallel analysis described by Griffing (1956b) and estimates of D_R and H_R, the additive and dominance components of variability. They observed both theoretically and experimentally that the genetic expectations of σ_g^2 and σ_s^2 for method 1 model II are identical with the general definitions of $1/4D_R$ and $1/4H_R$ for model II only when estimates from diallels involved a large number of parents.

Comparison of the different diallel approaches

Hayman (1960) compared the three approaches of diallel cross expounded by Griffing (1956b), Jinks and Hayman (1953) and Kempthorne (1956). The methodology of Jinks and Hayman (1953) followed the model I of Griffing (1956b), while Kempthorne's (1956) method lay in the domain of model II. Griffing (1956b), however, used both models. The second difference was on the basis of the statistical and genetical models of gene action. Here Griffing (1956b) utilized the former one, while Jinks and Hayman (1953) developed the methodology to estimate additive and various kinds of dominance components while Griffing (1956b) and Kempthorne (1956) estimated general and specific combining abilities. The analysis developed by Gardner and Eberhart (1966) was based on the fixed effect model (Baker, 1978).

Conclusions

It has been argued by Arunachalam (1976), Hinkerlamnn (1976), Kempthorne (1976) and Mayo (1980) that the genetically informative but relatively assumptionless analysis of Griffing's (1956b) method is to be preferred over that of Hayman's (1954b) approach. However, Griffing's (1956b) methods 1 and 3 provide a test for the assumption of Hayman's (1954b) analysis, with no differences between reciprocal crosses. However none of these methods provide a test for the assumptions of non-allelic interaction and linkage equilibrium. The test of these assumptions is provided by the method of Hayman (1954b) and Jinks (1954). Mather and Jinks (1971) concluded that Hayman's (1954b) analysis is the most useful for determining the significance of principal genetic components. Baker (1978) suggested that Hayman's (1954b) approach could be followed when the parents of the diallel cross have been produced by a random mating followed by nonselective inbreeding. In cases where these requirements are not met, the analysis should be limited to combining ability for estimating g.c.a. and s.c.a. mean squares and effects. For the development of synthetic cultivars, he proposed that topcross or polycross progeny analysis would be better than that of diallel analysis for measuring the general combining ability. Pooni et al. (1984) also concluded that for measuring the genetical component of variation and for testing the assumptions on which the estimates are based, the diallel is not a preferred design. They proposed that a triple test cross (Kearsey and Jinks, 1968) might be more appropriate.

It is, therefore, evident that from some points of view the data obtained from a diallel analysis are somewhat limited and could be obtained from other types of genetic experiments. This, however, is no argument against dialle experiments as they present a very convenient (from the researcher's standpoint) method of generating this type of data. Using in addition other types of crosses, such as backcross, etc., may increase the amount of information. At the same time this may lead to other difficulties; for example, generally more generations will be involved, and thus the problem of genotype-environment interaction cannot be neglected. Also the decision of what exactly is the relevant reference population may not be entirely clear.

While Hayman's (1954b) analysis is particularly useful for evaluating the mode of inheritance, the analysis of Griffing (1956b) is useful for the selection of desirable parents and cross combinations. Hence, it is obvious that the two methods together provide more useful information on the mechanism of inheritance than each does by itself.

Acknowledgements

I am grateful to Dr. K. R. Sarkar, Maize Geneticist and Mr. D. Singh, Senior Scientist (Statistics) of Indian Agricultural Research Institute, New Delhi, India for their kind help in preparing this manuscript.

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Acta Agronomica Hungariba 37 (3—4), pp. 353—375 (1988)

SPECIALIZATION IN HUNGARIAN CATTLE BREEDING AND LESSONS DRAWN FROM IT

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(Received 27 January 1986; accepted 21 July 1986)

"Responsibility for what we do is more and more extended by the responsibility for what we fail to do because of a lack of adequate information. I think the latter is today more important than the former."
(Arthur Horn, 1973)

One of the most important tasks of livestock polcy in Hungary is to improve the cattle branch. In the history of the Hungarian livestock farming, lessons can be drawn from the consequences of some important events over the last century.

Historical survey

The first major change occurred when the Hungarian grey podolian cattle from the group *Bos taurus primigenius*, which supplied mostly meat and draught power and only very little milk, were in the first decades of the century gradually replaced by the Hungarian spotted cattle, a breed of Simmental character. The cause was the intensive development of agriculture and of dairy management. In the course of this dramatic change, accompained by strong professional controversy, the share of the Hungarian podolian cattle in the cattle stock of Hungary was reduced from 80.3% in 1884 to 31.1% by 1910 and to a mere 10% by 1938. (A stock of several thousands of this breed, a valuable gene reserve, is expertly protected as a national treasure).

Agricultural production in Hungary between the two world wars bore the marks of a situation where 53.5% of the arable area of the country was possessed by big- and medium landowners, 34.2% were small- and medium peasant holdings, and 12,3% were lands smaller than 3 ha owned by subsistence farmers and agricultural labourers. The 1.9 million cattle- and 0.9 million cow-stock followed only approximately in proportion to these property relations. It contributed to the supply of the domestic and foreign market by producing an average of 95 thousand tons of beef and veal and 1.5 thousand million annual litres of milk. Under the maintenance conditions of those days, milk production per cow did not reach 1600 litres in spite of the joint efforts of government organizations, internationally recognized scientists (Újhelyi, I., Wellmann, I., Csukás, Z., Schandl, J., Konkoly-Thege, S., Horn, A., etc.) and development breeders.

The catastrophic losses caused by World War II in the cattle stock could be recovered to some extent only by the beginning of the fifties. In the meantime, however, with the land reform — which greatly affected the property relations — 58.2% of the area of the former big estates was distributed among the claimants; and on 26% of it, state farms and -forestries were established.

By the early sixties the large-scale reorganization of agriculture was completed so that 15% of the total agriculture area became state- and 78% cooperative property. More than half of the cattle stock and 47% of the cows were owned by large-scale farms. They supplied 63% of the slaughter cattle and 47% of the milk production of the country (1965 data). To maintain a steady level of production during this reorganization was an ordeal that required great efforts from the Hungarian agriculture.

The composition of breed in the cattle stock was at that time quite peculiar, as 92% of it was represented by Hungarian spotted, some 2% Swiss brown type animals and about 6% by other breeds and crosses. According to a publication of the "European Simmental Federation" (1966) Hungary was the only country in the world where the proportion of the Hungarian spotted cattle, a breed belonging to the Simmental (Fleckvieh) group was so large. The values of the Hungarian spotted cattle—a breed originally developed under somewhat primitive maintenance conditions — lay in its sound constitution, high capacity of meat production, and in the excellent quality of its meat, which was appreciated even on the foreign markets. On the other hand, the genetically determined milking capacity of the breed is only 3000–3500 kg (with a 3.8–3.9% butterfat content) (Horn and Szebenyi, 1955), and it was also inferior to the other European double purpose breeds in other milking characteristics. Its unbalanced qualities — while a potential advantage for purposeful selection work — made the management of milk production in large-scale dairy farms difficult.

It is also necessary to point out that the Hungarian dietary habits are rather special. While the annual per capita meat consumption already exceeded 55 kg in the sixties, nowadays 80 kg the proportion of beef and veal did not even reach 15%. At the same time, the average domestic consumption of milk and dairy products (without butter) was only 100 kg or so, far below the European average. (Today it is about 200 kg per capita). Consequently, the total milk yield of the stock but only half of the slaughter cattle production satisfied domestic consumption. The other 50% of the latter was an important source of national income until the restrictive import measures of the Common Market countries began in 1974.

It was thus quite natural that in the sixties the breeding efforts were concentrated first of all on improving the Hungarian spotted cattle stock. These efforts were manifested in

— keeping the total large-scale stock of cattle under breeding- and production control;
— elaborating and introducing up-to-date selection methods (breeding stocks, planned mating of bullraising cows, progeny test, etc.) (Bocsor, Csukás, Horn, Guba, Kecskés, Konkoly, Magyari, Márkus, Schandl, etc.);
— artificial insemination of more than 90% of the female stock with the modernization of this technology (Mészáros, Becze);
— starting an internationally integrated breeding work with leading countries (Guba, Németh, Szmodits);
— modernization of feeding (Baintner, Berke, Biró, Bocsor, Csukás, Guba, Tangl, Urbányi, etc.);
— improving the technology of cattle fattening and calf raising (Bárczy, Bocsor, Czakó, Guba, Kállai, Kralovánszky, etc.);
— modernizing the maintenance technology (Bocsor, Czakó, Guba, Kappéter, Molnár, Szaleczky),
— making machine milking in large-scale cow-stocks a general practice (Berke, Czakó, Csiszár, Csiffó, Dohy, Guba, Illés, Katona, Munkácsi, Patkós, Szajkó),
— completing the TBC elimination, and raising an efficient guard against brucellosis and rearing diseases (Kovács, Manninger, Mészáros, Mócsy, Szent-Iványi, etc.).

However, the leading personalities of livestock farming in Hungary tried to exploit other possibilities which promised a more rapid progress. Many of them were well aware of the fact that, with a single-breed double-purpose stock, the problem of cattle farming cannot be solved. Thus, Horn had already called attention to the necessity of specialization in 1949. This inspired the executives of the Ministry of Agriculture, under Minister F. Erdei, as well as their researchers, to start a crossing work in the early fifties with the purpose of developing stocks with a better milking capacity. From the mid-fifties onward, wide farm-scale experiments were carried out with foreign breeds used for crossing purposes acclimatization. Crossing of outstanding importance were Horn et al.'s Danish Jersey ("milk-type Hungarian brown" of 50% and "milk-type Hungarian spotted" of 25% Jersey gene ratio) and Magyari's kostroma (covering Hungarian spotted and Hungarian grey stocks) programs. By the end of the sixties their order of magnitude occasionally exceeded even 10–10 thousand cows. Crossing of minor importance included Piacsek's transforming crossing of the Swiss brown type breed (fused into the kostroma); the Red Danish crossing (later included in the Jersey crossing) directed by Márkus then by Mrs. Guba, and later by Dohy and Szuromi; Sebestyén's crossing of Red and white dutch Friesian lowland cattle, and finally Szuromi's Ayrshire experiment.

The idea of importing European lowland breeds Dutch Friesian was promoted by Felszeghy in 1958, but was realized only seven years later when the new industrial dairies of state farms were stocked in an order of several thousands.

The series of meat-purpose experiments was opened by a model experiment of Angus and Hereford crossing carried out by Horn et al. (1956) — first with the assistance of J. Hammond, professor of Cambridge using deep-frozen sperm — without any demonstrably important results. Németh (1961) carried out examinations with a minor Angus and Charolais strain.

In the middle of the sixties Magyari et al. suggested the use of Limousin in Hungary. On Izinger's initiative a Hereford stock of several hundreds was imported; the results justified his action. In the second half of the sixties Harsányi and Munkácsi started successful experiments aimed at developing the Hungarian spotted beef-cattle ("Dália" programm). That is why the Simmental later gained ground in the overseas countries where it has since been ever increasingly used as a crossing partner to improve the meat production. Despite these various new attempts the development of cattle breeding failed to meet the objectives. Specifically, the period between 1960 and 1970 was characterized by the following statistics:

— the number of cattle per 100 ha agricultural area was only 27 in Hungary, compared for example to 62 in the United Kingdom and 95 in the German Federal Republic. The density of stock in Hungary was thus far behind that in the developed livestock farming countries. The cow stock did not increase, despite substantial government support, though at the same time the sectoral rearrangement was considerable (Fig. 1);

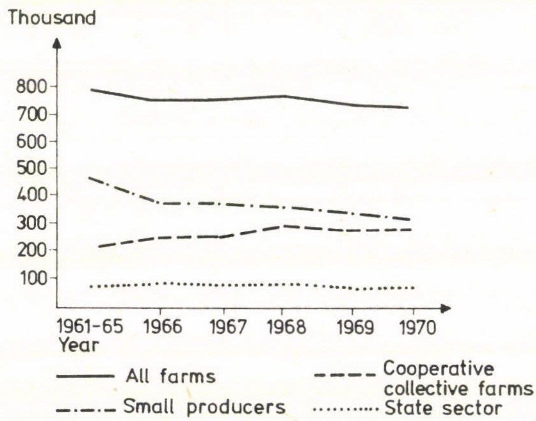

Fig. 1. Cow stock

— milk production per cow in Hungary was only 2500 l on a national average, while for example in the United Kingdom it was 3800 l or more and in the German Federal Republic it exceeded 3600 l. In Hungary both the specific output and the total production showed decreasing tendencies (Figs 2 and 3);

— otherwise, slaughter cattle production expanded, (Fig. 4) thus enabling an increase in exports.

The causes hindering the expected development of the branch were:

— owing to the invariably unfavourable maintenance and feeding conditions, only about 70% of the genetically determined production potential of the stock could be realized;

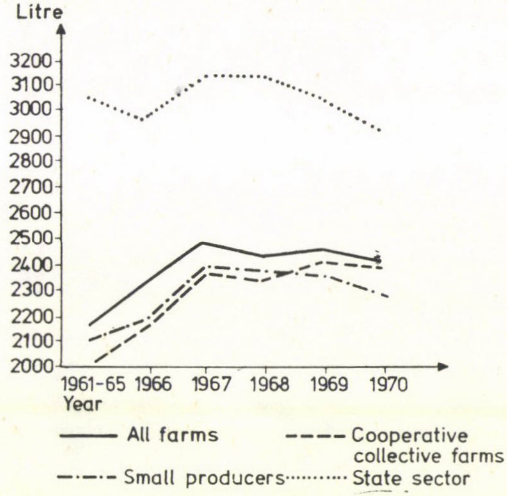

Fig. 2. Milk production per cow

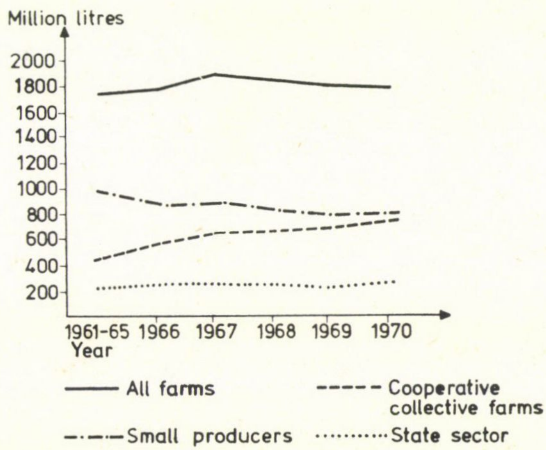

Fig. 3. Milk production

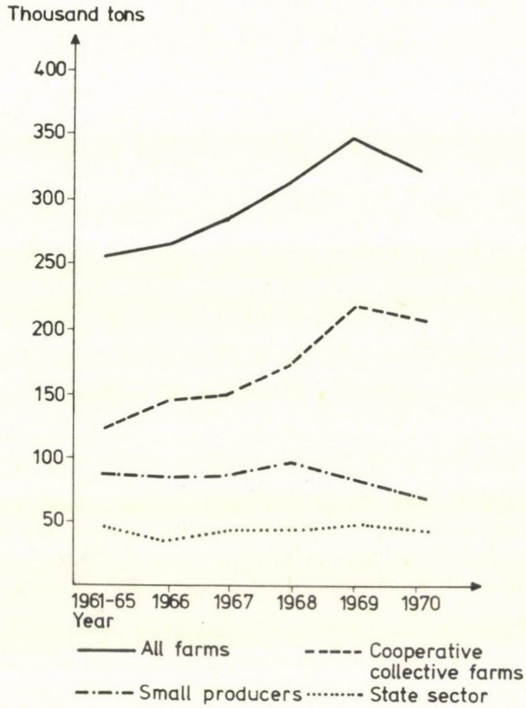

Fig. 4. Slaughter cattle production

— owing to the low level of milk production — in spite of the considerable state subsidy granted — products were turned out at low economic efficiency. The Hungarian spotted stock was generally unsuitable for efficient machine milking, a practice indispensable under large-scale conditions;

— owing to the expensive investments and the labour problems of carrying out production in outmoded buildings, the inputs were not refunded; hence most managers of large-scale farms regarded cattle breeding as a "necessary evil".

Despite the unanimously positive results of the crossing experiments mentioned (Jersey, Kostroma, Red-Danish, then later Ayrshire) they did not become widespread in Hungary in consequence of a certain degree of over valuation of the Hungarian spotted breed caused by the extensive slaughter cattle export. Only the Jersey crosses spread to a notable extent in the state farms, in which the professional staff was receptive to this novelty and, due to the higher technical level, specialization became an urgent need.

Otherwise, it was obvious, that the simple population structure could no longer be maintained and any progress to be made would require the fastest possible improvement of the "biological basis", the genetic capacities, within the given breed that could not be resolved by selection alone. It is understandable, then, that the experts' attention turned to high-capacity specialized breeds which when acclimatized or used as crossing partners, were expected to solve the problems of the cattle branch. The greatest interest was aroused by the USA-Canadian Holstein-Friesian cattle. Horn had already suggested in 1963, when returning from his lecturing tour in the United States of America, to try the Holstein breed in Hungary. However, the official circles did not then show much interest in the matter. The opinions of those believing in the Hungarian spotted cattle were still decisive at that time.

The change of view was greatly promotioned by the papers and lectures of Horn and Bozó (1969), Horn, Izinger and Kazareczki (1969), Gergely (1970) and Izinger (1972). They gave scientific support to the new direction of the breeding policy and were also able to refer to definite results from Hungarian experiments. Accordingly:

— with 160 doses of Holstein-Friesian sperm received as a present from Canada, first in 1966 Horn inseminated in Hungary a Jersey-blood stock thereby founding the popular "Hunarofriz" breed;
— Fülessy and Simon-Ruszinkó in 1968 started farm-scale red-Holstein × × Hungarian spotted crossing in state farms marked out for this purpose;
— the first Holstein-Friesian stock (35 heifers, 1 black spotted-, 1 red Holstein- and 1 Hereford bull) imported by Horn in 1969 was financed by the Bábolna State Farm. This was followed by imports of several thousand heifers to other farms (Agárd, Enying, Martonvásár, etc.) and by purchases of bulls and sperm for the main artificial insemination stations;
— the Hereford stock developed in Izinger's initiative, and the Limousin stock established on Magyari's suggestion, encouraged other state farms to establish stocks of several thousand of these breeds. At the same time upgrading crossing and combinative crossing started with the mentioned breeds for the purpose of producing breeding stock and animals for fattening had yielded similarly favourable results.

With the import of new breeds, up-to-date maintenance and feeding technologies were introduced and widely spread in Hungary.

Following these briefly outlined favourable developments, a government proposal was formulated that when accepted in 1972, became a new milestone in the history of Hungarian cattle breeding.

This government decision (No. 1025/1972) aimed at placing cattle breeding on totally new basis. The large farms were given the task of specialization, which meant the establishment of industrial milk production systems on the one hand, and on the other the introduction of single-purpose modern beef-cattle farming, a branch hitherto totally unknown in Hungary.

Results of the government decision aimed at developing the cattle branch

Milk-oriented specialization

On the basis of preliminary genetic calculations (Bozó and Dunay 1972) the branch development programme marked out the USA-Canadian Holstein-Friesian breed as the formative base of dairy-type stocks and was used in three ways:

— pure-breeding of imported stocks;
— breed transformation by up grading crossbreeding;
— combinative crossing by the joint use of Holstein-Friesian and Danish Jersey cattle.

This third method produced the Hungarofriz cattle (Horn, Bozó, Dohy and Dunay 1984), a breed officially registered in 1984.

In the state farms the large-scale crossing work began in October 1972, while in the cooperative farms only some 1.5–2 years later, mainly for conceptional reasons. The main line was the transformation grading up of the Hungarian spotted breed by crossing it with the Holstein-Friesian breed, because this promised the simplest and most rapid way to put an end to the pressing shortage of milk. Prior to launching the crossing programme, extensive breeding organization was carried out. To produce the necessary breeding bulls and accelerate the process of specialization, Hungary purchased more than 22,000 Holstein-Friesian heifers from the United States and Canada by 1982.

Today the population of pure-bred Holstein-Friesian cows exceeds 24.000 and with this stock Hungary is one of the largest pure-breed Holstein-Friezian gene bases in Europe. This population, the bull-raising cows (bull dams) in particular, are inseminated with the sperm of top progeny-tested bulls, continuously being purchased from the United States and Canada. Seventy per cent of these bulls come from the first 100 on the "top"-list of the USA.

For the work of breeding and crossing Holstein-Friesian cattle Hungary has imported a lage amount of sperm, as well as many breeding bulls and embryos, most of them from the United States. A total of about 200 bulls, nearly one million doses of sperm and 1500 embryos of Holstein-Friesian breed came into the country, mostly during the last 15 years. In order to produce the Hungarofriz breed, several thousand doses of Jersey sperm were imported from Denmark, and also alpine (mainly Austrian and Bavarian) spotted breeding material to improve the Hungarian spotted breed. Furthermore, Hungary imported several thousands of European (black and red spotted) Lowland heifers, though primarily for the purpose of increasing the stock. Their use either for pure-breeding or for crossing did not meet the expectations.

In Hungary Holstein-Friesian sperm is used at present for the insemination of 84% of the cow stock of large farms. The change in the composition of breed is clearly seen in Table 1 which shows the distribution of controlled cows ($n = 379,597$) representing 65% of the total dairy stock at the end of 1986.

Considering that in 1974 the double-purpose Hungarian spotted cattle represented 92% and Holstein-Friesian and Holstein crossbreed cattle a mere

Table 1

Distribution of the controlled milk-cow stock ($n = 379,597$) of Hungary on 31 December 1986

Hungarian spotted	6.00%	
Holstein-Friesian (H-F)	6.32%	
Black spotted H-F crossbred	42.46%	80% H-F blood
Red spotted H-F crossbred	29.05%	
Hungarofriz*	5.68%	
Other**	10.49%	
	100.00%	

* A breed produced by combinative crossing between Holstein-Friesian and Danish Jersey cattle.

** Breeds and crossing constructions below 1.5%, and cows of unidenfied genotype.

0.3% of the total cattle stock of Hungary, while today more than 85% of the active breeding material is of Holstein origin, anyone can recognize the revolutionary change that has taken place in this field.

As seen from Table 2 the cattle stock of Hungary has undergone a structural rearrangement too.

Table 2

Distribution of the cattle stock of Hungary, production and consumption of milk (1972–1986)

Year	Cow (1000)			Total number of cows (.000)	Meat-purpose cows (.000)	Total number of cattle (.000)	Milk production		Milk- and milk product consumption per capita
	state sector	cooperative sector	small producers				total million, kg	per capita, kg	
1972	94	331	337	762	3	1893	1596	154	116
1973	91	362	333	186	15	1930	1730	166	112
1974	94	388	314	796	30	2017	1796	142	119
1975	102	380	278	760	56	1904	1767	168	127
1976	106	396	264	766	63	1887	1873	177	136
1977	109	412	260	781	64	1949	2078	196	144
1978	114	415	259	788	67	1966	2206	213	153
1979	118	414	240	772	72	1925	2383	223	160
1980	122	418	225	765	74	1918	2471	231	166
1981	124	422	213	759	76	1945	2600	243	172
1982	127	425	203	755	80	1960	2628	246	175
1983	124	422	189	735	97	1951	2725	254	180
1984	123	415	187	725	106	1969	2725	254	180
1985	124	387	177	688	97	1766	2693	252	185
1986	123	382	171	676	95	1725	2652	250	185

Since 1972 until 1984 the number of dairy-cows in the large farms has grown by more than 110 000 (from 425 to 538 thousand), while the cow stock of small producers has regrettably been decreasing from year to year, despite generous state subsidization. Compared to 337,000 in 1972, only 187,000 cows were in private possession in 1984. This decline can be attributed mainly to an improvement in the social conditions of the village population, and to the effect of urbanization. Since 1984, the number of cows decreased in the cooperative and private sectors as a consequence of economical factors (Table 2).

Between 1972 and 1982, the total volume of milk produced increased by 65%, the per capita milk production by 60% and the per capita milk consumption by 51%. This expansion appears all the more remarkable as the stock of milked cows decreased by 20% during the same period. When the cross-breeding programme started, the TBC- and brucellosis eradication of the total cattle stock of Hungary was completed. Finally modern milking-house and free-open maintenance technologies and new feeding systems were introduced and became widespread.

The growth of milk output per cow was altogether spectacular. As seen from Table 3, the government programme on cattle breeding, which may certainly now be considered historically significant, led in the past 14 years to *an about 90% growth of milk production per cow, on a national and state farm average alike.* This is unprecedented worldwide! The 5529 kg production average of the state farms is particularly valuable. If this were the national average, Hungary would be among the 7 countries with the highest milk production per cow in the world. The supply, and with it the consumption of

Table 3

Commercial production average per cow on a national scale and in the state farms

Year	National average		State farm average within	
	kg	%	kg	%
1972	2363	100	2942	100
1973	2458	104	2103	105
1974	2478	105	3304	112
1975	2411	102	3326	113
1976	2706	115	3669	125
1977	2937	124	4085	139
1978	3137	135	4377	149
1979	3401	144	4582	156
1980	3612	153	4662	158
1981	3831	162	4854	165
1982	4023	170	5046	171
1983	4444	183	5235	178
1984	4330	183	5320	181
1985	4400	186	5334	181
1986	4490	190	5529	188

dairy products, have increased. Beyond the domestic supply, the dairy industry of Hungary realized profitable exports of 30–35 million dollars a year.

In order to determine what price in slaughter value of fattening bulls was to be paid for the increased milking capacity of the cow stock, the researchers carried out series of fattening experiments. The major meat production indices of milking genotypes occurring in the largest population are summarized in Table 4. The Hungarian spotted cattle, a breed of renown on the

Table 4

Meat production of dairy bulls

Characteristics	Hung. spotted 100%	Holstein-Friesian		Hung. spotted × Holst.-Fr. (F_1)		Hungarofriz	
		abs.	rel.	abs.	rel.	abs.	rel.
Final fattening weight, kg	532	532	100	572	108	536	101
Weight gain, g	1083	1023	94	1121	104	1053	97
Starch equivalent/1 kg weight gain, kg	4.1	4.4	107	4.0	98	4.2	102
Slaughter, %	58.7	57.1	97	57.5	98	57.1	97
Fat, %	5.0	5.4	108	6.0	120	6.2	124
Boneless meat, %	75.3	72.2	96	72.9	97	73.6	98
Bone, %	16.0	18.2	114	17.1	107	16.7	104
Bony meat/day of life, g	574	539	94	616	107	554	97
Boneless meat/day of life, g	432	389	90	449	104	408	94

Fatting: mass fodder supplemented with concentrate

international slaughter cattle market even today, is undoubtedly the best in an overall evaluation. Despite the changed composition of stock, Hungary exports more than 50% of the beef produced, mostly to new markets.

According to the preliminary genetic calculations (Bozó and Dunay, 1972) the Holstein-Friesian and Danish Jersey breeds were the most suitable for the purpose of dairy industry and the combination of the two breeds promises particularly outstanding results. The same conclusion was drawn by Lerner and Donald (1966). Furthermore, the realization of this fact in the German Democratic Republic resulted in a government programme on cattle breeding, and the same line has been followed in New-Zealand, a country known to be the greatest dairy-produce exported of the world (Stichbury 1982).

The results gave sweeping evidence of the correctness of the preliminary genetic calculations. Table 5 clearly shows the superiority of genotypes specialized for milk production to the Hungarian spotted cattle.

The first and average lactation production of breeds and crosses reared in the largest populations is contained in Tables 6 and 7.

Table 5

National production averages in the 1st lactation period
(1 January 1975–30 June 1978)

Denomination	Hungarian spotted*	Holstein-Friesian	Hung. sp. × Holst.-Fr. (F_1)	Hungarofriz
Number of cows	13 422	12 357	16 464	2 784
Age of first calving, months	28.9	28.9	26.8	26.3
Max. daily milk, kg	13.0	22.7	18.2	19.3
Milk, kg	2 761	5 233	3 997	4 218
Butterfat, kg	108	175	151	173
Butterfat, %	3.91	3.34	3.78	4.10
Persistence	73	77.5	76.0	75.7
Days between calvings**	403	406	373	369

* Baranya country (Southern Transdanubia).
** I—IV. lactations.

Table 6

First lactation production by cows of breeds and crossing constructions kept in larger populations in a 305-day period of 1984

Designation	Number of cows	Age at first calving (month)	Lactation production			Persistance
			milk, kg	butterfat, kg	butterfat, %	
Hungarian spotted	5 007	30.4	3318	126.4	3.80	71.9
Holstein-Friesian	6 085	28.6	5746	200.1	3.48	74.5
Holstein F_1	25 275	29.0	4228	154.9	3.66	72.9
Holstein R_1	32 752	28.5	4492	163.4	3.63	73.6
Holstein R_2	7 824	27.6	4857	175.5	3.61	72.4
Hungarofriz	5 418	28.8	4327	175.8	4.07	72.4
Total	95 965	28.7	4394	161.0	3.66	73.1

Table 7

Average lactation production of breeds and crossing constructions kept in larger populations in a 305-day period

Designation	Number of cows	Average lact.	Days of milking	Milk, kg	Butterfat		Time between calvings
					kg	%	
Hung. spotted	25 769	3.5	288	3896	147.0	3.77	406
Holst.-Fr.	18 921	2.5	296	6187	214.3	3.45	417
Holstein F_1	116 790	2.8	291	4868	178.2	3.66	403
Holstein R_1	70 280	1.8	292	4938	179.3	3.63	399
Hungarofriz	17 737	2.6	291	4812	193.0	4.01	397
Total	249 197	2.6	291	4882	179.0	3.67	403

In spite of the mostly unsatisfactory management conditions, the often objectionable technological level and the occasionally resulting feeding deficiencies, the production results attained are acceptable. The production level of the Holstein-Friesian stock which represents the main base of breeding may provide reasons for satisfaction. Its average 6187 kg lactation production per cow withstands criticism. It is especially promising that for the last four years an annual genetic progress of 85 kg in milk production has been registered, which proves the success of breeders.

The genetic progress made in the Holstein-Friesian breed extended also to the Holstein crosses. Form 1981 to 1984 the average milk production increased from 4467 to 4868 kg in the F_1 and from 4701 to 4938 kg in the R_1 generation (75% H-F), which corresponds to a 100 and 59 kg growth of milk, respectively, a year. In the same period the lactation milk production of the Hungarian spotted stock also increased by 117 kg, which indicates an annual improvement of 29 kg.

The dinamic development of the cattle branch has arisen in the past 15 years from a successful cooperation with the Holstein Breeding Association of the United States.

The economic changes in recent years have unfavourably affected the cattle branch of Hungary. For reasons outside the branch, the input costs increased radically while the price of milk did not practically change. The fact that the branch could overcome these difficulties is due first of all to the growth of production resulting from the changed composition of the stock, and partly to the rational, inexpensive maintenance systems.

Meat-oriented specialization

The development of dairy-type stocks was only one line of the initial specialization. The other task was to produce single-purpose beef-cattle populations.

In Hungary the question of single-purpose beef-cattle keeping is even today a controversial subject in professional circles. The opinions differ not only on the subject of the breed or genotype to be kept; many even query the rationality of this branch. However, the existence of single-purpose beef-cattle stocks in Hungary is made reasonable by two factors:

— cow-stocks of high milk-yield specialized for milk production have gained ground at the expense of the conventional Hungarian spotted cattle of double purpose;

— utilization of existing grazing areas and hitherto wasted by products (maize-stalk, grain-straw, grasslands, etc.).

Namely, the high expenses of establishing large-scale dairy farms make it imperative to produce the required amount of milk with the lowest possible number of cows. But this in turn automatically involves a reduction in the number of calves, the most decisive factor in meat production.

Table 8 clearly shows how the production of beef for one person decreases with the increasing milk production per cow. Calculations by Sándi (1980) made it obvious that, in the case of a considerable increase in the average

Table 8

Beef production (kg) per dairy cow for one person with differences in production and consumption

Designation		Average milk consumption per cow			
		3000	4000	5000	6000
		litre			
Milk consumption,	litre	Beef production for one person, kg			
	200	16.6	12.5	10.0	8.3
	250	20.8	15.6	12.5	10.4
	300	25.0	18.7	14.9	12.0

milk production of cows, the present per capita beef production when based of cows, the present per capita beef production when based on cows yielding milk could not even be maintained with an increase in the average milk consumption. In the case of an average milk production of 6000 litres this process would ultimately put a stop to either the export or the domestic consumption of beef, the latter of which, with its quantity of 10 kg/head, is in any case extremely modest. Besides, the level of exports maintained, an increase in the share of beef consumption from the total domestic meat consumption is also a primary interest. While in recent years the per capita production of pork and poultry meat increased by 34 kg, as also did the ratio of these kinds of meat within the total meat consumption, the fact that beef consumption has remained on the mentioned low level gives cause for thought. For each kg of pork and poultry meat to be produced (including the egg production) 0.55–0.60 kg protein feed has to be imported and paid by foreign currency, while the production of beef can be practically solved without importing protein feeds.

The other, similarly important aspects of the problem is the "by-product" utilization. According to calculations by Guba and Babinszky, in the case of a more than 4000 kg milk production or in the course of intensive fattening, only 5% of the starch equivalent requirement can be supplied by these by-products, while the starch equivalent requirement for keeping beef-cows and raising heifers can mostly be satisfied by them. The only way to solve all these problems and exploit the possibilities rationally is to develop the single-purpose beef-cattle branch.

At present (1986) 95,000 beef-cows are kept in Hungary without milking. According to various calculations it is possible to increase this population.

Single-purpose beef-cattle keeping in its present form is a totally new branch in Hungary. However, in recent years it had to be realized that neither its technology nor its breedeing aspects were as simple as originally thought.

Yet, some conclusions have already been drawn. The only product of beef-cattle keeping is the calf that can be used for fattening. For this very reason it can be economically reared only on pastures which cannot be profitably used for more intensive cultivation. It should not occupy important fodder crop areas, and feeding in winter must also be based on feedstuffs that could not be rationally given to milk-cows or other domestic species. A further demand in keeping beef-cows is the dispensability of permanent buildings.

As proved by the experiences and research results of the past fifteen years, the breeding tasks appear to be a complex problem in the single-purpose beef-cattle branch. Namely, in developing dairy stocks there is a possibility of producing a nearly optimum type that yields a plentiful and concentrated milk, regularly calves and accomodates itself well to the industrial conditions of production. In beef-cattle breeding, conversely, it has been established that no optimum breed exists, and the attempt to develop one would be in vain. In particular the qualitative features most important from the point of view of calf production, such as early sexual maturity, easy calving, moderate body weight, etc. are genetically antagonistic to the most important characteristics of the end-product, i.e. the beef-cattle. These are delayed fat deposition, good flesh conformation, high and long-lasting increase of weight, etc. For this reason the optimum solution is a radical separation of the maternal and paternal lines.

Practice followed the realization of this fact. While parallel with the single-purpose beef-cattle production based on dairy stocks, a programme initiated by Horn et al., breed transformation upgradine programmes with Hereford and Limousin cattle used for crossing were launched at the beginning of the seventies under the guidance of various enterprises and institutions. The pure-breeding of the Hungarian spotted breed as beef-cattle ("Dália" programme) was set as an objective, but the situation has by now radically changed. Besides the Hungarian spotted breed that satisfies special export demands, increasing attention is paid in the large farms to three-way crosses in various combinations, when crossbed cows are inseminated by some larg framed bull (Charolais, Limousin, Hungarian spotted, Blonde d'aquitaine) (Fig. 5). The examinations have proved that the demands raised on the meat-producting male line are relatively easily met by several breeds, such as Hungarian spotted, Charolais and Limousin. Otherwise the demands raised on the ideal female line, are so manifold that they can

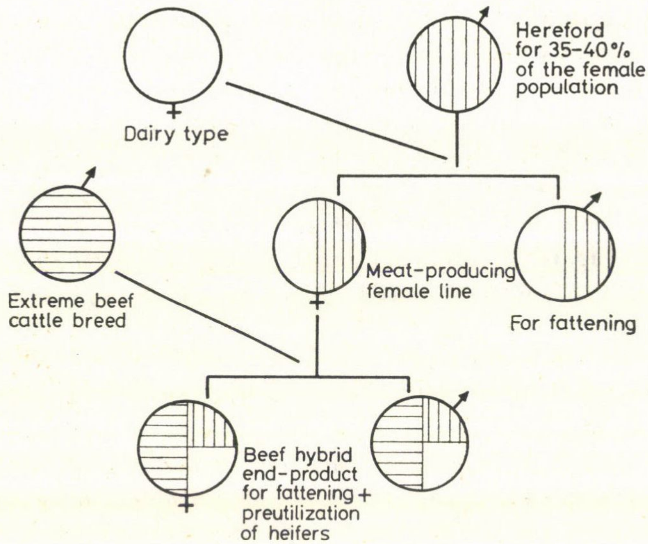

Fig. 5. Scheme of developing a meat-purpose mother cow stock based on dairy populations

mostly be satisfied only by a population produced with the exploitation of the possibilities of combination (Complementarity of types).

The qualitative features, combinative abilities, adaptation to various conditions of the different breeds, genotypes, and crossing construction have become known through the activity and publications of many researchers and practitioners.

These studies mainly covered:

— the propensity to fattening and the slaughter value;
— the fertility and calf-rearing ability;
— the adaptation to various technological conditions of each genotype;
— the size of population, the method of insemination (natural or artificial), and the seasonality of calving;
— the manifestation and extent of heterosis;
— the interactions of various qualitative features.

One of the ways of establishing a maternal stock is to produce a meat-purpose population based on dairy stocks. The essence of this method elaborated by Horn and his collaborators is, that, under normal conditions of veterinary hygiene and reproduction biology the completed population of female progeny is not required to maintain a dairy stock of definite size. At the same time great enterprises and national interests are involved in increasing the meat-producing capacity of dairy-type stocks. Therefore a proportion of the female population in the dairy stock may be inseminated with the sperm of single-purpose beef-cattle breeds. The bulls thus obtained will show an improved propensity of fattening and higher slaughter value while the heifers can form the basis of a meat-productng female line. This maternal-stock, whose replacement is ensured by a population derived from crossing carried out in the dairy-type populations in order to produce commercial animals, will throughout its life be inseminated by meat-type bulls producing an end-product meeting the market conditions (male line). The heifers are made to calve when young and are than slaughtered (preutilization of heifers). In that way the farms specialized for milk production develop the meat-producing maternal stock and its replacement as though it were a by-product. Thus the gene composition of the meat-producing female line can be made steady and optimum. From this point of view it is remarkable that, according to genetic considerations and experiences gained so far in large farms, the Jersey breed plays a highly important role in shaping the desirable properties of the meat-producing female line. Early sexual maturity, easy calving, concentrated milk production that is less affected by unfavourable environmental conditions, high fertility, and low requirements for subsistence are in particular those characteristics in the Jersey breed which are of primary importance in the meat-producing female line. A similarly favourable crossing partner is the Hereford, since it does not require much care and makes good use of extensive grasslands.

One of the bases of the programme is the maximum exploitation of the effects of heterosis in each phase of production. Today there is hardly any, up-to-date breeding programme in beef production that would not want to use the heterosis effects ("type-heterosis", Horn, 1979) for its purposes.

According to some noteworthy conclusions drawn from foreign and Hungarian investigations, the effect of heterosis appears more explicitly under the conditions of a lower production level. Studies of crossing beef-cattle breeds have revealed that by systematic crossing a 20–25% accumulative heterosis effect can be achieved. This 20–25% production surplus represents such an attractive amount that it cannot be rejected.

However, the heterosis can be fully exploited in each phase of production only when the whole breeding work is systematically organized.

The most expedient way of making use of the heterosis effect is a continous reproduction of the mother cow population by crossing with a male line that satisfies the current market demands. *One of the best possibilities is offered by using as meat-purpose mother cows' heifers obtained by crossing milk-cows with Hereford- or other small framed beef-cattle with low demands.* In this case the lower producing individuals of the dairy stock, not required for the latter's replacement, can be mated with small framed beef bulls of low demand, and the resulting heifers, as mother cows will all their lives be *inseminated with a breed of a paternal line with good flesh conformation* (Fig. 5). *In that way a dairy stock of thousand cows can maintain a meat-purpose herd of 600 mother cows* whose replacement is always produced in the dairy population. *With preutilization of heifers introduced this number can be raised to over 1500.* Further advantages of this method are that, with the right male line chosen, the most extreme fluctuations of the market can be easily counterbalanced, and in the case of an occasional depression the beef cattle stock can be decreased at any time; while in an improving market situation the necessary number of single-purpose meat-producing cows can be reproduced at once. Such a degree of adaptability can at present be attained by no other breeding method.

Single-purpose beef-cattle production based on dairy stocks, a method carried on since 1969 in Hungary, has by now become a practice, which simultaneously offers the possibility of a very wide and successful cooperation among the cattle farms. With the development of dairy stocks the interest in this method continually increases and in the future it will certainly be the most widespread method of beef-cattle production. Finally the biotechnical methods now in the process of relaization (embryo transplantation, sex determination, etc.) indicate almost boundless perspectives for the future.

In the beef-cattle branch expedient technological solutions, low-cost keeping forms without buildings, feeding systems based on by-products (maize stalk grazing, preservation and storage of fresh beet slices), various grassland management methods, etc. have been introduced. Important information has been obtained concerning the size of stock, the means and seasonality of insemintaion and the influence of other factors on the success of breeding. It can be safely said that it is no longer any lack of knowledge that hinders the development and efficiency of beef-cattle farming in Hungary. For the fact that the beef-cattle branch as a whole still does not develop at the planned and expected rate, the present economic conditions are partly responsible.

Hungary is an example of how a small sountry can raise its rather outmoded cattle branch to an international standard in a relatively short time; if its objectives are clear, it finds the best way to achieve them, joins the international activity and is not ashamed of learning from more expert sources. If the country wants to progress — and the increasing economic competition does not allow other alternatives —, it must proceed in this direction.

The prospects of cattle farming in Hungary

As for the development of the Hungarian cattle branch expected until the end of this century Bíró and Dohy (1982) presented a forecast that was discussed between the joint Committee on Animal Husbandry of the Hungarian Academy of Sciences and the Ministry of Agriculture and Food. The prediction makes the following points:

On considering the further possibilities and determining the tasks of the cattle branch, Resolution No. 1025, 1972 (a government programme on the development of cattle breeding) remains the most reliable basis. The specialization of production, along with the coordinated development of biological bases and environmental conditions will invariably be the fundamental principles. To reach an annual per capita consumption of 270 litres of milk (and dairy products) represents a further prospective task, as at present the country is far below this level (with its annual 180–190 litre milk- and dairy product consumption per head). As to the situation of beef consumption the present annual per capita beef consumption of approximately 10 kg is expected to remain unchanged. Some 50% of the slaughter cattle and beef produced can be exported in the future as well although with the increasingly keen competition for markets Hungary must improve its competitive strength. This primarily requires a reduction of the prime cost of exportable beef.

It must be considered that the marked demands on slaughter cattle and beef differentiate as the price ratios change (often unfavourably for Hungary). Besides maintaining the traditional markets, often distant ones must be acquired and held. For markets with a sound demand, the beef must therefore be exported in adequate quality, choice ad package at the required time, while the possibilities of improving the efficiency of production must be continually exploited.

A projection for milk- and slaguhter cattle production up to the year 2000 is seen in Table 9. Now at the century's end, some 650,000 cows may be capable of producing an amount of milk representing the equivalent of 270 litres per capita. In the case of a lower consumption of milk and airy products (regrettably due to the unfavourable demographic conditions and prospects of the country) 600,000 cows specialized for milk production will be sufficient to supply the necessary amount of milk (even enabling occasional exports), whereby the meat-purpose stock can be increased. Nearly 65% of the total slaughter cattle production will come from the dairy type stock, along with a considerable extension of the meat-oriented specialization.

Since a continually increasing proportion of milk is processed and the costs of milking as well as of milk transportation and -processing are rising, it is expected that in certain regions of the country the so-called industrial milk will be produced on a larger scale. This calls for an economical production of milk with higher butterfat- and protein content, which ban be achieved through the systematic work of crossing the Holstein-type cow population with Danish Jersey bulls. This programme can be continued with the Hungarofriz breed registered in 1984. The combination of the Holstein type- and the Jersey population may lead by the end of the centruy to 200,000 crossbred cows, with about 5000 kg milk-, 4.5% butterfat- and 3.65% protein production a year on the average. This stock can at the same time be characterized by a moderate concentrate consumption and optimum rough- and mass fodder utilization.

Table 9

Production projection for milk and slaughter cattle

Type of the cow stock and product	Unit of measure	Year		
		1990	1995	2000
Dairy type	1000 cows	510	540	565
Milk				
per cow	litre	5200	5600	6000
total	million litre	2652	3024	3390
Slaughter cattle				
per cow	kg	420	420	420
total	1000 t	214	227	237
Double purpose	1000 cows	140	110	85
Milk				
per cow	litre	3700	3900	4000
total	million litre	518	429	340
Slaughter cattle				
per cow	kg	420	420	420
total	1000 t	59	46	36
Meat type	1000 cows	135	180	230
Slaughter cattle				
per cow	kg	450	450	450
total	1000 t	61	81	103
Cow stock grand total	1000 cows	785	830	880
Milk grand total	million litre	3170	3453	3730
Slaughter cattle grand total	1000 t	334	354	376

The double- (milk-meat) purpose stock is expected to decrease further, and the number of cows of this type will hardly reach 100,000 (partly regarded as a "nucleus" population reasonably used to bring forth a beef-producing male line).

The cattle stock of the small producer sector integrated by the socialist large farms will be further reduced, yet in the long run it will represent important reserves.

In the work of breeding and improving the dairy type stock, the Holstein-Friesian breed will remain of decisive importance; its gene basis must be made available for the breeding programme by the continued production and import of both sperm from bulls of high breeding value and deep-frozen embryos derived from "supermating". Also an active participation in the international breeding cooperation can in the future be an important factor in the development of cattle farming in Hungary.

With the goal of rendering the meta-oriented specialization more effective and economical, a breeding- and production cooperation between the "production systems" must be maintained, as well as the establishment of widely propagated meat-purpose "mother cow" stocks through a systematic crossing of dairy- and meat type populations. For this purpose the domestic breeding bases mostly are availabe, or can be established with the development of an international cooperation ("nucleus" stocks of special beef-breeds: Charlais, Limousin, Hereford, etc.).

In large-scale farms- and even more so in the framework of their horizontal and vertical integration — milk — and meat oriented specialization can be so based on one another that beef- and milk production can be economically developed by making optimum use of the ecological and economic conditions.

For the future of cattle breeding in Hungary the question of how rationally the achievements of, biotechnology and electronics will be adapted, may become the crucial element in raising the efficiency of breeding work to a still higher level.

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Acta Agronomica Hungarica 37 (3–4), pp. 377–385 (1988)

Lectures

BENEFICIAL EFFECT OF TECHNOLOGY ON NATURAL RESOURCES IN FIELD CROP PRODUCTION*

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(Received 9 June 1986; accepted 30 September 1986)

A social demand of our times on agriculture is to produce increasing volumes on a decreasing productive area.

This can be achieved where

— production is based on varieties of higher yield potential, and the technological elements that ensure the reliability of yield are applied on a high level, and
— the technology increases the natural resources.

The beneficial effect of technology on the natural resources can be planned when the relationship between technological elements and fertility are known.

Keywords: soil fertility, basis of yield, determination of yield, reliability of yield, natural resources

Introduction

Between 1950 and 1980 the agricultural area declined from 7,375,500 ha to 6,601,200 ha and the arable area from 5,518,100 ha to 4,734,700 ha in Hungary; that is, by 774,300, and 783,400 ha, respectively. Hungary belongs thus to those countries where the agricultural area decreases in an absolute sense. The worldwide agricultural area per capita becomes continuously less and less.

Parallel with the reduction of the agricultural are the demand in Hungary grew from 5.5 million tons in 1950 to 16 million tons for grains crops, from 1.6 to 5 million tons for sugar-beet and from 0.19 to 0.8 million tons for oil-seeds (Fig. 1). The yield of grain crops on a world scale increased by 1982 to 1,695,000 tons compared to 690.9 million tons in 1948–1952, while

— the sowing area only grew to 734,897 from 610,500 ha, and
— in grain crop production per capita the progress on a world scale diminished.

* Lecture on the Scientific Days of Gödöllő, 1–3 February 1986.

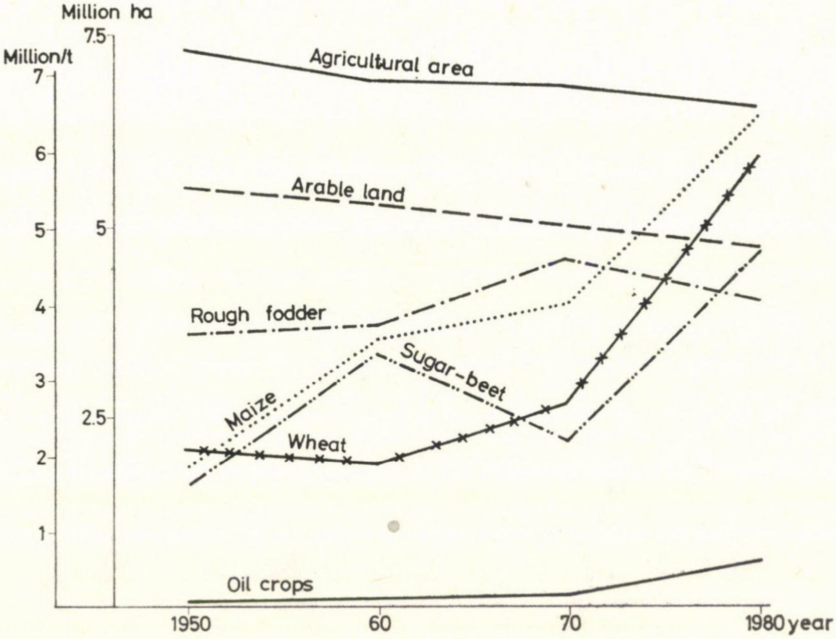

Fig. 1. Trends of the agriculturally useful area and the volume of produces

Effectiveness of precipitation as a function of technology

One of the decisive factors of the yield average is the water that agriculture requires primarily through precipitation in most areas of the world. The amount of precipitation — though varying annually — fluctuates around a definite value. It is therefore important to know how much the available water determines the yield increase.

It has been proved that the transpiration coefficient, a factor known from the literature, can be useful in answering the above question if its value is considered as a function of soil fertility and size of yield.

Győrffy (1983) indicated the importance of studying the yield average per 100 mm precipitation with maize. We accordingly examined the trend of the average yield of wheat per 100 mm precipitation between 1950 and 1980 — in relation to the above mentioned dynamic growth (Table 1). We found that

— between 1951 and 1955 its value was 199–583 kg in the 4 countries examined, while

— in 1980 it ranged from 338 to 710 kg,

— that is, in 30 years a 58–511 kg increase of value was shown.

The average wheat yield per 100 mm precipitation increased from 291 to 707 kg in France, and from 199 to 710 kg in Hungary. Of the countries examined these two showed the most impressive change. The change was smaller in

Table 1

*Yield of wheat per 100 mm precipitation (kg)**

Year	France	Denmark	Italy	Hungary
1951–1955	291	583	240	199
1956–1960	273	580	206	267
1961–1965	399	657	242	308
1966–1970	447	634	291	394
1971	554	899	368	668
1972	567	827	288	508
1973	726	777	347	869
1974	584	824	366	572
1975	535	1156	357	615
1976	532	916	279	579
1977	466	657	327	732
1978	676	686	302	717
1979	542	596	303	575
1980	707	641	338	710

* Calculations by dr. M. Hajdu.

Italy and Denmark, although its extent significantly differed for the two countries.

These data clearly show that the complex effect of precipitation depends rather more on the level of production and technology than on the regional characteristics.

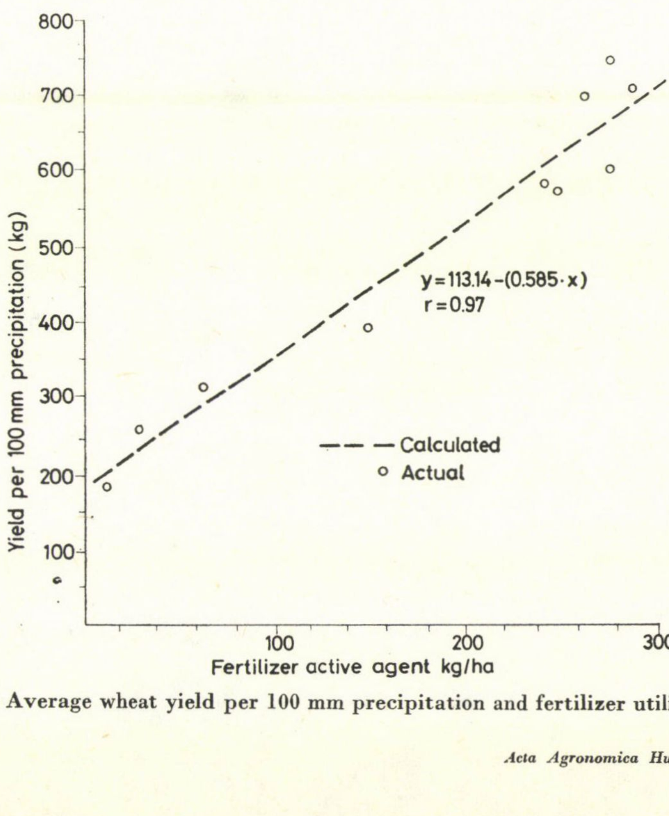

Fig. 2. Average wheat yield per 100 mm precipitation and fertilizer utilization

In Hungary, for example, the yield average per 100 mm precipitation shows a close correlation (Fig. 2) with the NPK active agent applied $\big(r = 0.97, y = 113.14-(0.588 \cdot x)\big)$.

That is to say, the effect of precipitation as one of the most important natural resources can be quantified. The ratio of yield average per 100 mm precipitation between two dates shows the relative change in the effect of precipitation. For example, precipitation in Hungary was 3 1/2 times more effective in 1980 than in 1950.

Improvement in the effectiveness of precipitation becomes particularly obvious with an increase in the quantity of NPK active agent per unit of arable area; namely, the yield surplus of wheat per 100 mm precipitation is

— 100 kg/ha with 100 kg/ha NPK active agent,

— 250–300 kg/ha with 200 kg/ha NPK active agent, and

— 500 kg/ha with 300 kg/ha NPK active agent used.

This indicates at the same time the gradually increasing role of technology under the conditions of intensive production and a relative modification in the role of the natural factors. This statement was confirmed by a correlation examination performed for the period between 1970 and 1980 which revealed a $r = 0.59$ correlation between the yield average of winter wheat and the amount of precipitation (Fig. 3). that is, the correlation became less close compared to the earlier literary data.

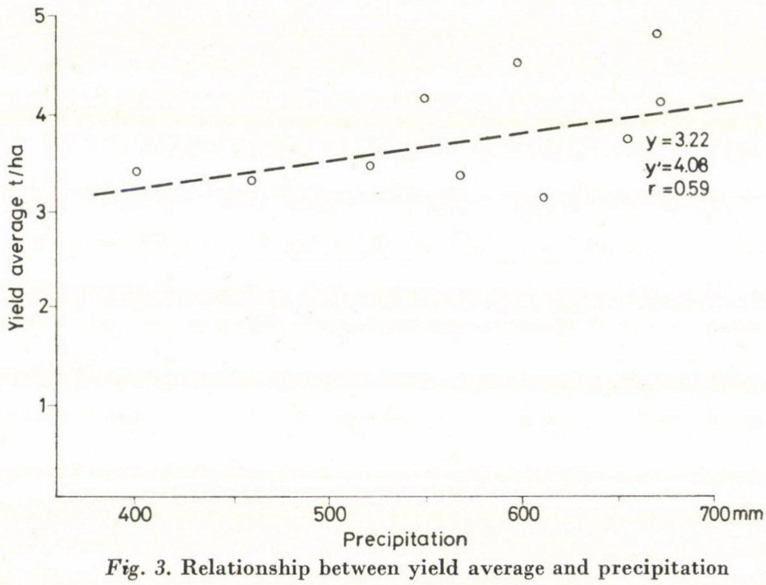

Fig. 3. Relationship between yield average and precipitation

The role of soil factors in connection with the technology

On evaluating the role of the soil factor we accepted the present system of initially grouping the soils by gold crown value. That is, to characterize the fertility of a soil we took its gold crown value for a basis. (This naturally covers various soil types.) On this basis we examined the correlation of the yield averages of wheat, maize, sunflower to the fertility of soil (Fig. 4). We found that the correlation between the soil fertility and the yield averages of the mentioned crops was extremely close, more so than between the precipitation and the yield average.

Thus, under intensive management conditions the role of the soil factor increases.

Stefanovits (1981) makes a distinction between the basic and the actual fertility of the soil. The basic fertility practically indicates the level of a technology based on hand- and draught-power using materials of agricultural origin. However, with a knowledge of the basic and actual fertility, the questions can be answered of how and to what extent the fertility of soil changes during any given period. In Hungary the production level of the 1930s can be considered suitable for characterizing the basic fertility of its soil. Accordingly, by the 1980s the fertility of soil — when measured with cereals — grew more than threefold.

—The fertility of soil changes as a function of the technology applied.

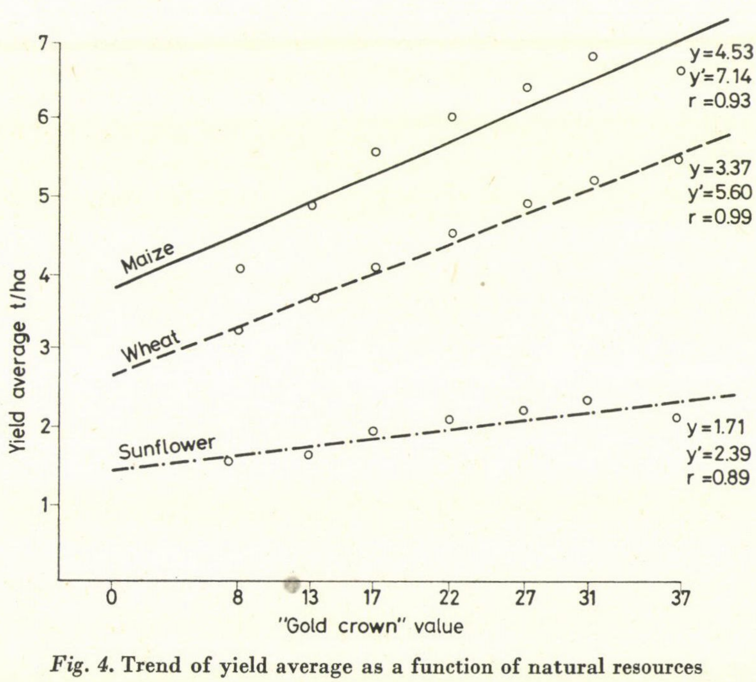

Fig. 4. Trend of yield average as a function of natural resources

Role of the factors of technology

Technology in field crop production consists of 4 factors: biological, agrochemical, technical and human resources. The role of these groups of resources differs in shaping the yield. In most yield analyses the role of the resources is expressed in a percentage with that of the yield and yieldsurplus taken for 100.

According to Schuster (1970) breeding has an average share of 45% in increasing the yield. Bunnies (1973) attaches lower importance to the role of changing the variety (weighted average: 38%). Kapás (1978) expresses the opinion that the change of variety in wheat and maize is responsible for 30% of the increase in yield average. According to Balla (1986), under intensive technological conditions, the role of variety in increasing the productivity rises; in the case of wheat it is about 48%.

The role of the agrotechnical factors can also be quantified. Győrffy (1983) gave an example of this when analysing the factors of maize cultivation. Jolánkai et al. (1986) found the yield-increasing effect of the agrotechnical factors in wheat production to be 6.2–49.6%. However, interactions between the factors modify these values. Hajdú (1985) pointed out an effect ranging between 11% and 46% in potato production.

Today the role of technology in shaping the yield should — in our opinion — be approached in a different way.

The new approach starts from the assumption that *the factors of technology* can be placed in three groups: factors *forming the basis of yield*, factors *determining the yield* and those *increasing the reliability of yield* (Hajdú 1986).

The basis of the yield is provided by the biological resources: the production potential of the variety of hybrid, the time of sowing, and the number of plants per unit area. They give the potential framework of the attainable yield and hence they are called the factor that forms the basis of yield.

Resources determining the yield are the nutrient replacement and the irrigation, since the yield average actually attained depends on how much nutrient and water (possible minimum factors) are available compared to the potential productivity of the variety (or hybrid), and to what extent the demand for them can be satisfied.

Since the actual yield average is also a function of soil fertility, and in the case of soils of different fertility the yield that ensures maximum income can be attained with different rates and ratios of fertilization, it is necessary to determine the yield level for a variety (or hybrid) with the natural resources taken into consideration.

Factors acting on yield reliability are plant protection, plant tending, and harvesting. The costs of these technological elements should be regarded as an integral part of the technology, and the technological level and costs indespensable for the reliability of yield are reasonably determined as a function of yield average and income.

The role of technological elements is many-sided; e.g. soil cultivation through its direct and indirect effect both determines the yield and ensures its reliability.

Planning the effect of technology on the natural resources

When planning the technology so as to increase the natural resources we must start from the interaction of technology and yield average.

With the extent of a known genetic progress, the level of the production potential of a variety or hybrid can be predicted, or in the correlation system of variety — seed propagation — variety trial — breeding (Fig. 5) 3–5, 5–12, 12–15–20 years can be forecast.

According to Kapás the increase of annual average yield differences, compared to Bánkuti 1201, is 60 kg. That is, on the basis of the genetic progress 7–8 t/ha national average wheat yield can be expected by the year 2000.

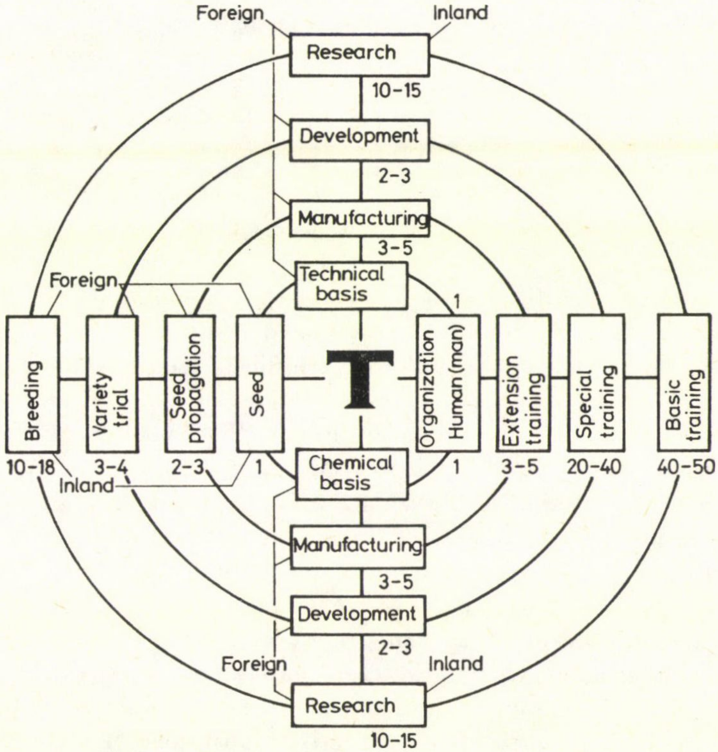

Fig. 5

In the Hungarian agriculture the turnover of variety is dynamical. The average lifetime of wheat varieties commercially produced in 1980 is 5.3 years, that of maize hybrids 3.72 years (it is 5.3 for sunflower, 6.0 for sugar-beet and 14.07 for alfalfa).

Thus, from the standpoint of breeding it can be practically established that the wheat varieties possibly cultivated at the end of the century will possess a production potential of 10–14 t/ha.

The signalling system of productivity increase is thus ensured for the future.

The question is what can be expected from those resources of technology which determine the yield and result in yield reliability.

A study of the process of fertilizer production-trade-development-research (Fig. 5) calls attention to the following facts:

— on improving the fertilizer production the demands of plant and soil must be increasingly taken into consideration and a greater harmony created between fertilizers and fertilizer distributors, so as to ensure a uniform distribution,

— reducing the amount of nutrients required for producing 1 kg dry matter is one of the objectives of breeding. While there are results in this field, no spectacular change can be expected until the end of the century. The present production level in wheat has been attained with 300 kg/ha NPK active agent which increased the fertility of soils by 416%. However, for a 8–10 t/ha national yield average an NPK active agent supply of about 450–500 kg is necessary on a national scale,

— the choice of fertilizer must be modified; on the one hand the proportion of nitrogen fertilizers must be increased, on the other hand the trade of fertilizers of physiologically neutral pH-value has to be promoted and new forms of fertilizer with new characteristics manufactured. By these means leaching can be lessened, the demand of in plant during the vegetation period more uniformly fulfilled, unavailability of chemical bonds decreased and even an ameliorative effect achieved,

— organic- and inorganic fertilization must be considered in interaction, and the use of biofertilizers increased in proportion to the increase in the amount of inorganic fertilizers. Greater attention should be paid to the application of by-products in improving the fertility of soil. With the process of pesticide production, -trade, -development and -research known (Fig. 5) the reliability of yield can be planned.

This process is in some ways more favourable, but in others less favourable than the fertilizer-chain which now determines the yield. It is more favourable in the sense that the choice of pesticide is relatively wider, the research work and experimentation with new protective substances is more advanced. However, it is less favourable in that, for the use of the existing up-to-date materials up-to-date equipment is not always available; there exists a fundamental inconsistency between these two elements.

According to Békési (1986) only a third of the pesticides used today is really effective, another third is superfluously applied, while the remainder loses in effect owing to the outmoded system of instruments.

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Acta Agronomica Hungarica 37 (3–4), pp. 387–392 (1988)

ECONOMIC EFFICIENCY OF DAIRY POPULATIONS AS JUDGED BY SECONDARY PARAMETERS AND RELATIVE LIFE PERFORMANCE*

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(Received 10 April 1986)

Introduction

A superficial observation of the tendencies observed in practice may suggest that the specific milk production alone should be increased. In most cases consideration is given exclusively to the lactation production of individual cows or to the average lactation production of various populations (breeds, genotypes), though this does not give a sufficiently good reflection of economic efficiency.

Dairy farms are faced with the production costs of the cow, subsistence feeding according to body mass and operational costs, so the quantity of milk produced per cow would appear to be of decisive importance.

The productivity of populations cannot be judged by the specific milk production alone, since in practice secondary parameters often influence the economic efficiency to a considerable extent. This is particularly true of the long-term performance, which depends on the number of calves, the prolificacy and a good constitution.

In leading milk-producing countries an increase in the specific milk production was accompanied by a sharp reduction in the number of cows milked. Over a twenty-year period the individual milk production of a number of breeds rose from 3500 to more than 5000 kg, while the number of cows milked decreased by 40%.

Concern for the quantity of final product alone may be misleading and may have the consequence that, when evaluating breeds, populations or even dairy stocks, only the quantity of milk is taken into account.

Relative milk production has long been accepted as a standard of value; Brody and Ragsdale (indirect reference: Horn 1976) elaborated a productivity coefficient which made it possible to judge the milking capacity by taking the live mass of the cows into consideration.

Dunay and Dohy (1961) elaborated a relative milk production index which took the lactation yield, expressed in terms of 4% butterfat, and the

* Lecture held at the 36th EAAP meeting 1 October 1985, Thessaloniki, Greece.

square of the chest circumference into account; on this basis it was found that the most productive cows had an index value of 1300 kg; the value for good cows was 1000–1300 kg and for medium ones 800–1000 kg.

In order to compare the period of use with the life duration Dohy (1961) elaborated a "relative life performance index". He demonstrated the applicability of the index by means of model calculations and suggested its use in evaluating sows raising bull calves.

For the economic evaluation and comparison of breeds and genotypes, Szajkó (1984) elaborated a new index.

Aim of the investigation

There is a need for an index giving information on the capacity of individuals, breeds or populations and on performance as related to the whole useful lifetime, thus also providing and indication of the profitability of milk production.

The index should include the life performance, expressed in terms of milk with the same concentration, the date of first breeding, the calving interval and the body mass on the basis of which the FCM milk quantity related to a certain live mass and one day of life can be determined for each cow.

An examination must be made of the secondary selection parameters that ensure the evenness of the production process when milk is produced on an industrial scale.

Material and methods

When elaborating the index it is necessary to examine the factors that act on the economicalness of production. The mathematical method used should make it possible to assess the milking capacity and the economic efficiency on the basis of the data usually available.

The study relied on the available international and Hungarian data on breeds and populations. Individual and population production results were compared by model calculations with the aid of the index presented below, and indices were elaborated for registered breeds and Hungarian crosses.

Results and evaluation

The production relative to the whole useful lifetime gives a true picture of the capacities of an individual (or population). The following index calculation is suggested for this case:

$$\textit{R}\text{elative } \textit{L}\text{ife performance } \textit{B}\text{ody mass } \textit{I}\text{ndex (RLBI)} =$$

$$= \left(\frac{\text{Life performance FCM}}{\text{days of life}} \right) \text{kg} \cdot 100) : \text{average body mass kg}$$

On the basis of the formula, milk production (in FCM) per one day of life can be easily calculated and even alone gives a good indication of the economic efficieny of performance. The first quotient obtained from the formula contains the beneficial or detrimental influence of the early or late beginning of breeding, and of narrow or wide calving intervals.

This index is also an advantage because the production result per one day of life is a much better index than the milking result or the daily maximum or lactation production. Calculations can be made for the period of utilization instead of per day of life but the index thus obtained gives less indication of the economic efficiency.

If the milking result per day of life is multiplied by 100 and divided by the kg body mass the kg quantity of milk produced per 100 kg live weight per one day of life is obtained. The results deteriorate from the higher to the lower numbers. These data are not relative numbers, but actual values.

The calculation of the relative life performance body mass index is first illustrated on the basis of data for model cows.

Cow "A": life performance : 37,000 kg FCM milk; age when discarded (at the end of the last lactation): 11 years and 2 months (4075 days); average live mass calculated from data recorded annually: 715 kg

$$\text{RLBI} = \frac{37{,}000}{4{,}075} = 9.0797 \text{ milking result per one day of life (kg FCM)}$$

$9.0797 \cdot 100 = 907.97 : 715 = 1.27$, FCM milk kg produced per one day of life and 100 kg live mass.

Cow "B": life performance: 76,200 kg FCM milk; age at the end of production: 10 years and 4 months (3770 days);
average live weight: 675 kg

$$\text{RLBI} = \frac{76{,}200}{3{,}770} = 20.212 \text{ milking result per one day of life (kg FCM)}$$

$2{,}212 \cdot 100 = 2021.2 : 675 = 2.99$ kg FCM milk produced per one day of life and 100 kg live mass.

The milking result per day of life can be compared to the relevant daily costs of the farm. Life performance and live mass have a noticeable effect on economic efficiency.

The relative life performance body mass index (RLBI) shows the combined effect of many characteristics, including the reproductive capacity and the mutual compensation of the quantity and butterfat percentage of the milk production. Owing to the multifactorial character of milk production, the index provides information on totalled results and economic efficiency. The calculation can be used to compare breeds or genotypes, as seen in the following examples:

Genotype "A": — average milk production (FCM) 4100 kg;
— average number of 305-day lactation periods 2.7 (824 days);
— life performance $2.7 \times 4100 = 11.070$ kg FCM milk
— age at first calving 29 months (870 days)
— average calving interval 405 days
— average live mass 680 kg

Calculation of the age: calving age in days + [(number of lactations* —1) average calving interval] + last lactation in days. In the above example the age is thus $870 + (2 \times 405) + 213 = 1893$ days.

$$\text{RLBI} = \frac{11{,}070}{1893} = 5.84 \text{ quantity of milk per day of life (FCM milk kg)}$$

$5.84 \times 100 = 584 : 600 = 0.86$ kg FCM milk (100 kg live mass/day of life

Genotype "B": — average milk production (FCM) 4100 kg
— average number of 365 day lactation periods 4.8 = 1464 days
— life performance 19,630 kg FCM milk
— age on first calving 26 months = 780 days
— calving interval 380 days
— average live mass 440 kg

Age $780 + (4 \times 380) + 244 = 2544$ days

$$\text{RLBI} = \frac{19{,}680}{2{,}544} = 7.74 \text{ (FCM) milk kg per day of life}$$

$7.74 \times 100 = 774 : 440 = 1.76$ kg FCM milk/100 kg live mass/day of life

If the relative life performance-body mass index is not calculated the identical lactation milk productions of the two genotypes cover up the great difference in productivity. The milk productions per day of life, 5.84 kg for genotype "A" and 7.74 kg for genotype "B" show a totally different picture than when the lactatio ı esults are compared.

The difference is still greater when the final figures of the RLBI are considered: the quantity of FCM milk produced per 100 kg live mass for one day of life is 0.86 kg for genotype "A" and 1.76 kg for genotype "B".

* The number of lactation is rounded up (thus 3 — 1 = 2).

High RLBI values are attained by herds with good reproductive capacity, where selection on the basis of qualitative features can be carried out in the females as well.

The index (I) gives a complex expression of the life performance (L) relative (R) to the body mass (B).

Table 1 summarizes the performances of different breeds as expressed by the RLB index, for a varying number of lactations, i.e. for different useful lifetimes, on the basis of averaged international data obtained from many places.

Table 1

Evaluation of breeds on the basis of RLBI values (Relative performance per day of life per 100 kg live mass) (On the basis of international data averaged our many years)

Breed	Age at first calving		Calving inter-val, days	FCM milk, kg	Live mass, kg	Kg FCM milk per 1 day of life × live mass = RLBI for different lactations			
	months	days				1st lact.	2nd lact.	3nd lact.	4th lact.
European Black Spotted Lowland	27	810	400	5000	600	0.688	1.035	1.243	1.383
British-Friesian	27	810	400	4393	550	0.660	0.992	1.192	1.325
Danish Black Spotted	27	810	400	5140	600	0.708	1.640	1.278	1.421
Swedish Black Spotted	27	810	400	5971	600	0.822	1.236	1.485	1.651
Holstein-Friesian	25	750	400	5986	680	0.765	1.135	1.354	1.498
Dutch Red-Spotted Lowland	27	810	400	4603	650	0.585	0.879	1.057	1.175
German Red-Spotted Lowland	27	810	400	4544	650	0.577	0.868	1.043	1.160
Swedish Red-Spotted	26	780	400	5447	500	0.974	1.455	1.741	1.931
Angeln	26	780	400	4622	500	0.783	1.170	1.400	1.553
Danish Red	27	810	400	5000	600	0.688	1.035	1.243	1.383
Danish Jersey	24	720	400	5405	400	1.206	1.777	2.111	2.329
Guernsey	25	750	400	3763	460	0.711	1.055	1.258	1.392
Finnish Ayrshire	25	750	400	5623	500	0.978	1.451	1.730	1.914

Table 2 shows the RLB indices calculated from the average number of lactations for a number of genotypes. The figures prove that genotypes with lower body mass which produce more concentrated milk are much more

Table 2

Evaluation of various genotypes on the basis of RLBI taking the average number of lactations into consideration (Szajkó, 1984)

Breed	Age at first calving		Calving interval, days	FMC milk, kg	Live mass, kg	Average number of lactations	RLBI based on the number of lactations
	months	days					
Holstein-Friesian	28.9	867	417	5305	680	2.5	1.052
Hungarian Simmenthal	28.9	867	406	3639	650	3.5	0.875
Hungarian Simmenthal × Holstein Friesian	26.8	804	393	4297	650	1.7	0.797
European Red Spotted Crossed Lowland	27.0	810	397	3883	600	2.7	0.962
Hungarofriz "B"	26.6	798	396	4231	500	2.7	1.267
Hungarofriz "A"	26.3	789	393	4536	500	2.5	1.313

economical using official data, the genotypes were also compared after completion of the first lactation (Table 3). The data obtained in a complex evaluation of relative production thus indicated that small-bodied single-purpose dairy breed constructions were more favourable.

Table 3

Evaluation of various genotypes after completion of the first lactation
(Állattenyésztés, 31. 6.)

Breed	Age at first calving		Calving interval, days	FMC milk, kg	Live mass, kg	FCM milk kg/100 kg live mass/day (RLBI) 1st lact.
	months	days				
Hungarian Simmenthal	28.9	867	406	2719	650	0.328
Holstein-Friesian	28.9	867	405	4762	680	0.550
Hungarian Simmenthal × Holstein-Friesian	26.8	804	368	3877	650	0.508
Hungarofriz "A"	26.3	804	368	3877	650	0.508
Hungarofriz "B"	26.6	798	370	3792	500	0.649

The wide-scale introduction of the RLE-index is thus suggested to replace the usual method of evaluation and selection in cattle breeding, based on the lactation or annual milk production.

Summary

Economic efficiency of dairy populations on the basis of relative live performance

The economic efficiency of milk production is not adequately shown by the milk production data. Indices elaborated by weighting the different characteristics are of great importance.

It is necessary to elaborate an index giving information and the capacities of individuals or populations and on the relative performance over the whole lifetime. The index suggested by the author includes the life performance, the milk concentration the age at first calving, the calving interval and the body mass, expressing the milk production per one day of life and 100 kg live mass for the cows in a given population.

The "Relative Life performance Body mass Index" (RLBI) facilitated a proper evaluation of milking breeds and crossed populations in Hungary. The results show that small-bodied populations with good reproductive capacity, producing more concentrated milk and completing more lactations, are the most economical. Single outstanding lactation results have less influence on the value of the index. The detailed evaluation provides a sound basis for the correct selection of breeding trends and types.

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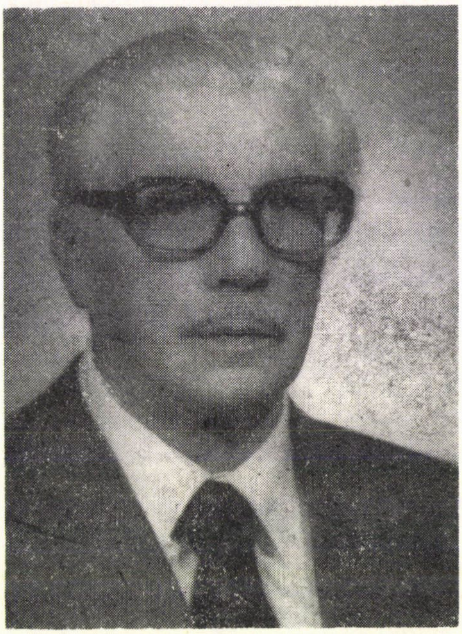
Obituary

Prof. Dr. Bohdan Dobrzanski
1909–1987



Professor Dr. Bohdan Dobrzanski emeritus professor ordinary of the Agricultural University in Warsaw, member of the Polish Academy of Science, foreign member of the Hungarian Academy of Science died on 15th July, 1987. Prof. Dobrzanski was born on 3rd March, 1909 in Strutynka, began his scientific work in 1933 at the Polytechnical University in Lwow, where he also obtained his doctorat.

In 1946 he organized and was head of the Chair of Soil Science at the University of Marie Curie-Sklodowska in Lublin. Faculty of Agriculture, afterwards in 1955 he created the Chair of Soil Science on the Faculty of Biology and Earth Sciences.

For nine years Prof. B. Dobrzanski was rector at the University of Marie Curie (1952–55) and later first rector at the Agriculture University in Lublin (1955–59 and 1968–69).

For his merits in the development of these Universities and for his scientific achievements he was honoured doctor honoris cause at both institutions and at the Agricultural and Technical University of Olsztyn.

In 1960 Prof. B. Dobrzanski was elected as a correspondent member and in 1969 as an ordinary member of the Polish Academy of Sciences. In 1960–1980 he was member of Presidium of P.A.Sc., in 1969–71 he was deputy and general scientific secretary of P.A.Sc. and in 1972–77 Sc. Secretary of Agriculture and Forestry Section in P.A.Sc.

Through 4 cycles he was chairman of the Committee of Soil Science and Agricultural Chemistry and through 2 cycles chairman of the Committee of Agrophysics.

In 1969 he was nominated director of the Soil Science Institute of the Agricultural University in Warsaw and he performed this function until 1979, when he retired.

On his inspiration the unique Institute of Agrophysics was established in 1968, as part of the Polish Academy of Sciences in Lublin. For many years he was director of this Institute and later chairman of its scientific council.

Prof. B. Dobrzanski was author or co-author of over 340 publications, maps and books. His achievement was the establishment and subsequent editorship of the "Polish Journal of Soil Science" and bulletin "The problems of Agrophysics."

He promoted 30 doctors of science, 12 of whom obtained the title of professor and several of associate professor.

Of particular value are his works on the genesis, systematics and evolution of soils, particularly rendzinas and on the dynamics of water retention and transmission in soils evolved from loess and sand. He was highly interested in the development of agrophysical research, with special attention to the basic physical processes in soils and the results of agrotechnical activities.

Of particular importance are his monographs, written in collaboration with other soil scientists; "The agriculture value of soils in Eastern Poland", "Rendzinas of the Lubelska Upland developed of carbonate rocks of Cretaceous period", "Typology and properties of soils developed from boulder loam of the middle-Polish glaciation" and "Surface area of arable soils of Poland".

His last publications were: 3rd edit. of the academic manual "Gleboznawstwo" — "Soil Science" with S. Zawadski and the monography "Morphology, structure and ultrastructure of silt grains in sandy soils of the Kampinos National Park" with Z. Brogowski and J. Kocon. In process of publication is a monograph written together with R. Turski about rendzinas in Poland.

Prof. Dobrzanski is well known as one of the creators of soil cartography in Poland. He is co-author of the Soil Map of Poland at the scale 1 : 300,000, main editor of Soil Map of Poland at the scales 1 : 500,000 and 1 : 1,000,000 with included soils characteristics and co-author of the Soil Map of Europe at the scale : 2,500,000 and 1 : 1,000,000 which were prepared at the initiative of FAO.

Thanks to his research and ability to collaborate with other scientists Prof. B. Dobrzanski has reached a position of eminence among polish soil scientists. He was elected member of the Hungarian Academy of Sciences, of the Soviet All-Union Agriculture Academy and of the Agriculture Academy of the German Democratic Republic.

He was also honorary member of the All-Union Soil Science Society and of the Soil Science Society of the Federal Republic of Germany.

For a decade Prof. Dobrzanski was foreign member of the Hungarian Academy of Sciences. He visited Hungary many times and conducted joint research with Hungarian soil scientists.

The memory of this brilliant personality and scientist will remain with all those who enjoyed his friendship over many years.

I. Szabolcs

REVIEWERS OF MANUSCRIPTS, VOLUME 37, 1988

Every scientific contribution in Acta Agronomica Hungarica is reviewed by two scientifically qualified persons. The Editorial Board is pleased to publish the following list of reviewers for the manuscripts of the 1988 issues, who by their unselfish contribution have significantly contributed to ensure the scientific standards of Acta Agronomica Hungarica.

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Book Reviews

The Food and Nutrition Bulletin is a quarterly published under the joint editorship of the United Nations University and the United Nations Sub-Committee on Nutrition as a continuation of the former PAG Bulletin.

Number 4 of Vol. 7 of the journal is divided into the following chapters: "Nutrition and health", "Food science", "Food and nutrition plicy". At the end of the journal there is a list of the institutions collaborating in the sub-programme "Food, nutrition and poverty" coordinated by the UNO University.

The papers contained in the journal deal with problems faced by the developing countries.

V. Valverde, H. Delgada, R. Flores, R. Sibrián and M. Palmieri, the authors of the paper "The School as a Data Source for Food and Nutrition Surveillance Systems in Centra America and Panama", give an account of a programme involving measurements of the body height of children entering school and investigations into the social status of their families. The evaluation of these data provides a reliable, low-cost index with respect to both nutrition problems and nutrition deficiency. A high mortaility rate in a community (or country) was found to coincide with reduced body height.

In a paper entitled "Asceriasis and Digestibility: A Study in Cameroonian Children" André Comu calls attention to the need to lay greater emphasis on public health and personal hygiene in order to stop, or at least essen, infections by intestinal parasites and olther pathogens.

Experiments conducted in four villages in the Punjab, India, are described by B. N. S. Walia, S. K. Gambhir, D. Kumar and S. P. S. Bhatia in the paper "Feeding from the Family Pot for Prevention of Malnutrition". On the basis of the experiment the authors are convinced that a large proportion of the population in the developing countries, where the children are undernourished, is unaware of the fact that children are quite capable of eating and digesting the food that the family consumes, that this would cause them to grow normally. According to the authors few families are really short of food. Malnutrition could be prevented and cured, in their opinion, if the children shared in the family meals.

The aim of the paper "High-protein Biscuits Made with Ragi Flour and Oil-seed Flour Blends" M. P. Vaidehi, Pushpa Bharati and Lelitha Reddy is to popularize the use of ragi, an important food for people in semiarid tropical regions. The authors mixed ragi flour with soya or peanut flour and made biscuits with it. Having compared the protein content and raw materials of the products thus obtained they found that, for the same price as traditional biscuits, products with a 20–70% higher protein content could be produced, though their organoleptic quality did not reach that of the control.

In the paper "Aid, Trade and Hunger", written on the basis of a survey made by the International Food Policy Research Institute in 1979, George Kent establishes the fact that in the 16 developing countries that reached the highest growth rate for food production between 1961 and 1976 food imports showed a simultaneous increase, though this did not necessarily reduce hunger. The study points out that while in most countries the average daily calory intake increased, the increase in calory intake by poor people came from the cheapest cereal-based foodstuffs. The income distribution favours the middle-class and the rich.

P. FÖLDHÁZY

L. H. MACDONALD: *Natural Resources Development in the Sahelv* the Role of the United Nations System.
— The United Nations University, Tokyo, 1986. pp. 95.

Originally the term "Sahel" — an Arabic word literally meaning "shore" or "bank" — had a specific geographic reference: the southern boundary, or "shore" of the Sahara, the variable zone between the extremely arid desert and the more humid savannahs to the south. This zone is some 450 km wide, and extends for roughly 5500 km between the Atlantic Ocean and the Red Sea, including significant parts of Senegal, Mauritania, Mali, Niger, Chad, Sudan, Burkina Fasso (Upper Volta), Nigeria, Cameroon and Ethiopia.

It was the 1968–73 drought that focused world attention on the Sahel region. An unusually poor series of wet seasons led to the failure of crops and the death of livestock on a massive scale and the pictures of malnourished children and dead cattle stimulated a tremendous outpouring of emergency relief. This short-term reaction has been followed by an international effort to aid the long-term development of the countries that are now commonly called the Sahel.

This excellent review of the joint efforts of different UN organizations and projects to bring relief to the plague-smitten nations covers not only the first (1968–73) but also the second (1983–85) period of drought. The UN University Arid Lands Subprogramme chose the theme "Assessment of the Application of Existing Knowledge to Arid Land Problems". A number of research studies were commissioned within the scope of this subject, examining the various interface that exist between scientific investigation and the application of its findings, often within a regional context.

This study also focuses on the problems of socio-economic development, environmental conservation, and the application of scientific knowledge and technological resources in the Sahel.

The author is an expert on desertification problems, working in this field in connection with UN programmes concerning the Sahel region. He gives an "inside" view of the structure and functioning of these aids, with all the problems involved. In the third chapter he gives a detailed account on the UN Development Programme (UNDP) and the UN Conference on Desertification (UNCOD, Nairobi, 1977).

The last chapter is devoted to conclusions. It is pointed out that development aid must be provided in a spirit of cooperation and without any preconceived ideas. Although the UNU's special Subprogramme on Arid Lands has now been concluded, the new programme on Resource Policy and Management has undertaken to maintain this international dimension in research, training and dissemination, stressing the interaction of resource management, conservation and development.

This volume is a very useful, authenthic source of relevant information concerning the whole complex of problems in the Sahel zone. Climatologists, ecologists, agro-economists and poltiticians should all find it valuable.

Z. SZŐCS

H. R. J. DAVIES (ed.): *Natural Resources and Rural Development in Arid Lands:* Case Studies from Sudan. — United Nations University, Tokyo, 1985. pp. 84*t*

In 1975 the Council of the UN University identified three priority areas for its concern — world hunger, human and social development, and the use and management of natural resources — and ordained that a programme should be organized in each of these areas. By early 1977 the Programme on the Use and Management of Natural Resources had itself identified a series of specific problem areas for its investigation (viz. environmental deterioration in the humid tropics, rural energy supplies, and the ineffectiveness of attempts to apply knowledge to the management and development of arid lands) and sub-programmes were developed in response to each of these. In 1977 it was decided to base the latter (the Arid Lands Sub-programme) at the University of Khartoum, Sudan. The following year a workshop was held in Khartoum, as a result of which a first series of five studies was initiated in Sudan during 1979 under the overall heading "Obstacles to the Application of Existing Knowledge in Arid Lands".

This volume contains the four studies in this series completed by 1982.

The first study deals with the production of dura *(Sorghum vulgare)* in Sudan and with the parasite buda *(Striga hermonthica)* which is the most dangerous weed of dura and other crops (millet, sugar-cane, maize, rice). It is concluded that without effective control of this aggressive weed, there is no way out of the present hopeless "circulus vitiosus" of the lifecycle of buda for the relatively poor, slimple rural society because the domestic livestock are the main distributional factor in the spread of the weed.

The second case study is about the impact of an improved rural water supply on the environment in the East Kordofan District (West Sudan). This area is traditionally a semi-arid one and generally characterized by a shortage of water, even drinking water. There is no question that the people need more new local sources of water (different kinds of wells), but experience shows that the inevitable consequence of opening up a new source is a quick concentration of people and a rapid growth of the population around it. This in turn usually leads to serious disturbances in and the deterioration of the fragile environmental complex. The author concludes that the best strategy is to allocate the new sources to local centres where the conditions required for future socio-economic development are already available.

The third paper is about the wood resources and their use in the Nuba Mountains (Kordofan provence, West Sudan). In arid and semi-arid regions with a rapidly increasing population, involving migration to the towns, the demands for wood fuel rapidly escalate. Locally available sources are necessarily limited and are often soon exhausted. In periods of severe droughts large numbers of rural cultivators and workers become destitute because of crop failure and loss of animals. Chopping down trees for sale is a temporary solution for such people, but at the same time it means an enormous pressure on the forests and trees within reach.

The fourth case study is "Planners' and participants' perceptions of development in the semiarid lands of Sudan: a case study of the Khashm el Girba Scheme". It is about the success and the unexpected reaction of the nomadic tribes in the area. The main conclusion is that various groups have widely different viewpoints and unless these can be brought more closely together, the scheme is unlikely to achieve a high degree of success. The main lesson for arid land development is the overriding need for a full assessment of the perceptions of the participants if success is to be achieved and waste minimized.

The whole volume is a valuable source for a deeper understanding of the main roots of the problems in arid land development. It will be of special use to students and university teachers dealing with the ecological, agricultural, social and economic aspects of these problems.

Z. Szőcs

RUDOLF HAGEMANN: *Allgemeine Genetik.* (Zweite Auflage) VEB Gustav Fischer Verlag Jena (1986)

Rudolf Hagemann's book "Comprehensive Genetics" has recently run to a second edition under the editorship of VEB Gustav Fischer Verlag Jena (1986).

Hagemann's name is familiar to all those who are acquainted with his works in the field of biological sciences. The author is a professor in the genetic team of the Biological Institute, Martin Luther University, Halle-Wittenberg. His present collaborators, Reinhard Piechochki, Frank Siegemund and Thomas Börner professor of genetics at Humboldt University, Berlin, also contributed to the first edition.

In the Preface Hagemann recommends the book to every representative of the profession interested in the subject, but especially to university students in the biological, agricultural and medical faculties.

The 542-page book is divided into 19 chapters; the 201 figures, 37 tables, and a chronological table in the Appendix on the results of genetic research together with a bibliography (for the 1st and 2nd editions) and a list of terminological references, contribute to better understanding and easier orientation.

In *the first two chapters* the tasks facing genetics, its place among the other sciences, the associated branches of science and the objects of genetic research are characterized. A survey is given of the genetic material of *Cyanobacteria*, bacteriophages and viruses.

Chapter 3 gives detailed information on the structure and regeneration of the genetic material, describes the types of cell division an by analysing the various phases of this division, discusses the structure of the chromosome, including different types, such as giant chromosomes, lampbrush chromosomes, etc.

Detailed descriptions are found in this chapter on the structure and recombination of the material carrying the genetic information, from the RNA of phages to the mitochondrial DNA of higher plants.

Chapter 4 uses well chosen models to illustrate the processes by which faulty genetic codes are repaired.

In *Chapters 5 and 6* mutational changes in the genetic material, the causes inducing mutations and the mechanisms and rate of mutation are dealt with, and gene, chromosome, genome and plasm mutations are analysed.

Chapters 7 to 9 describe the mechanism by which the genetic material is transmitted and reproduced in prokaryotes and eukaryotes. Differences in haplodiplotene recombinations, and the genetic control and cytoplasmic basis of crossing over are also dealt with.

Detailed descriptions are given of the phenomena and material of plasm transmittance. Examples are given of plastid and mitochondrial transmittance.

In *Chapter 10* a complex description is given of various types of cell biological manipulations; the results achieved so far in embryo transplantation, artificial insemination, nucleus transplatation, plasm exchange the fusion of somatic animal and plant cells, etc. are presented, together with future prospects in these fields.

This is followed by a discussion of the results and perspectives of genetic engineering, ways of choosing the DNA donor, and the role of DNA fragments and vectors. The isolation and "cloning" of chromosome parts, or DNA sequences, methods of in vitro coding and ways of applying them are also dealt with in *Chapter 11*.

Chapters 12 to 14 acquaint the reader with the concept and system of notation of the genetic code, the mechanism of transcription, the possibilities of transcribing errors, changes in the code due to mutations and cases of reparation.

Chapter 14 exposes the ultrastructure of the gene, analysing the concepts of genes, mutons, and recons on examples taken from the pro- and eukaryotes.

Chapter 15 introduces the reader to the operon theory of gene control, including regressive and inductive control and mutative changes in the function of the operon.

The author reveals the secrets of gene fusion (Chapter 16), a procedure which may promote the formation of intermediates, e.g. immunoglobulin genes.

Chapter 17 can be regarded as a special study on the mechanism by which primary genetic information is transmitted complemented by an analysis of the biochemical processes of gene interactions (complementaries, modificators, suppressors, polymery, etc.).

A large number of literary references and examples help to give a comprehensive view of the joint effects and interactions of sexual chromosomes and ecological factors. In this context the relation between genes and the plasm and the manifestation of their interaction are analysed.

Like other authors, Hagemann attaches special importance to methods for studying the rules of population genetics. He gives several examples of how to apply the Hardy-Weinberg rules, thus showing the possibilities of population genetic modelling.

The causes of genetic polymorphism and factors acting on the process of evolution, such as mutation, migration, selection, drift, fitness, change of allele frequency, genetic stress, etc. are all clearly explained.

Finally, references are made to fields where a knowledge of genetics may promote development in research and production.

This book by Hagemann and his co-authors presents the latest achievements in genetics in an up-to-date form. While it discusses the results of classical genetics, it also supplies wider and more detailed information on molecular genetics.

The book is clearly formulated; the examples and the reasoning are easy to follow. The figures and tables help to achieve an understanding of the subject. It will be a useful manual for the acquisition of a basic knowledge of genetics and for the recognition of its fields of application.

K. Mozsár

Hans Günther Dässler: *Einfluss von Luftverunreinigungen auf die Vegetation* (Ursachen–Wirkungen–Gegenmassnahmen). Dritte Auflage, VEB G. Fischer, Jena

This 223-page book presents the reader with an extremely topical subject in a clear, easily comprehensible form. In a total of eight chapters, the author discusses the damaging effect of air pollution on plants, illustrating his arguments with clear figures and sketches.

The *first chapter*, which also plays the part of an introduction, gives a brief historical review stretching from 1849 to the present day, demonstrating the significance of imission damage in plants and animals, and also from the point of view of human life. This chapter also contains an explanation of the terms and basic concepts used in the book (pp. 11–19.)

Chapter 2 gives a detailed review of the sources of air pollution, listing (in order of importance) the materials which play the greatest role in causing air pollution. These are sulphur compounds (SO_2, SO_3, H_2S), fluorine compounds (FH, CaF_2), chlorine compounds (Cl_2, HCl), nitrous fumes (NO, NO_2, N_2O_3, N_2O_4), ammonia (NH_3), ozone (O_3) and ethylene (C_2H_4). But polluted air also contains soot, ashes, cement dust and the dust of heavy metals. In connection with these factors, information is given on the types of power stations, factories, etc. from which they may originate (pp. 20–29).

The *third chapter* presents the reader with a description of various methods of analysis. Information is given on the spatial distribution of emission and immission, on ways of analysing the air, on various forms of sample taking, and on ways of evaluating the results (pp. 30–47).

Chapter 4 deals with the preconditions for immission and the effects exerted on plants. To start with, the reader learns how plants take up these noxious substances and what effect they have on various physiological processes as a function of concentration and time. Graphs based on specific examples and original measurements illustrate the reduction in assimilation and disturbances arising in respiration and the water balance. In this chapter the author also mentions biochemical effects forming the basis of physiological phenomena (changes in the reactivity of enzymes and isoenzymes, reductions in the quantities of organic acids, the stimulation of ethylene production, changes in pH values, etc). The chief emphasis in this chapter is on a description of the symptoms of damage, which are illustrated by extremely clear figures and colour photographs (pp. 48–76)

In contrast to the general conclusions found in previous chapters, *chapter 5* is devoted to the specific immission effects which can be observed in agriculture and horticulture. This includes a discussion of immission damage to the soil, to agricultural crops (fodder crops and grain fodder) and to horticultural plants. This is followed by a detailed description of damage caused to deciduous and evergreen trees. The chapter includes numerous tables and sketches, presenting the reader with complex information on sensitive and resistant species (pp. 77–119).

The *sixth chapter* discusses methods of estimating the damage on immission areas. Examples are given on how to apply analytical methods in soil and plant analysis. Mention is made of the importance of bioindicators. Methods of diagnosis and damage assessment are presented in the fields of agriculture, horticulture and forestry (pp. 120–143).

Chapter 7 discusses laws designed to maintain the purity of the air, and equipment suitable for the reduction of emission (pp. 147–157).

Chapter 8 is once again addressed to agriculturalists, horticulturalists and forestry experts, listing adaptive techniques which can be applied as preventive measures against the immission effects still to be reckoned with, e. g. stock replacements, choice of tree species, afforestation of areas surrounding industrial sites, etc. (pp. 158–185).

The *ninth chapter* contains final conclusions in the field or regional and construction planning (pp. 186–189).

Chapter 10 contains an abundant list of references (around 150 works), followed by a detailed subject index. The closing pages are devoted to a series of 15 photographs, some of them in colour.

I. Szalai

G. Sitkei: *Mechanics of Agricultural Materials*, Akadémiai Kiadó and Elsevier Publishing House, 1986

In previous centuries the properties of agricultural materials caused no particular difficulty, since the picking and preparing for market of easily damaged fruit were carried out entirely by hand, while the packaging materials used during transportation were chosen to protect the goods from damage as much as possible.

With the appearance and spread of large-scale mechanized harvesting, mechanical transportation, loading, and processing, the requirements which must be satisfied, when designing those tools and equipment that come into contact with the produce, have become considerably sticter.

Yet before the requirements can be satisfied, much more precise knowledge is needed on the parameters connected with kinetic forces acting on the produce. Until now, despite the relatively precise engineering design, practice has been based almost entirely on material parameters determined empirically, as the result of which the machinery and instruments manufactured and marketed were more expensive and caused greater loss and damage.

Among its other merits, György Stikei's book has the great advantage that it is the first in this field to give an uniform classification of the physical properties and the mechanical, thermodynamic, electrical and optical parameters of agricultural materials. It details the interactions between the liquid and solid contents of the materials, of the moisture exchange, of drying, and of the behaviour of the materials in the course of storage.

A no less important chapter of the book is devoted to rheology. Detailed information is provided on factors related to the deformations and creep occurring in the materials under the influence of various forces.

The second part of the book deals with correlations connected with mechanical damage, with the causes of this damage and possible ways of reducing it, and with aero- and hydrodynamic characters.

A related chapter concerns friction in the materials, and not only describes the general laws of friction, but also specifically assists designers in connection with the pressure exerted on the walls of receptacles, with outflow and with the movement of various kinds of materials. Of most practical use is the section on the dimensioning of receptacles.

The chapter on the concentration of materials provides extremely useful information for the designers of machinery for pelleting, and pressing.

Of the 18 chapters in the book, the last 2 deal with the cutting and chopping of agricultural materials and with the grinding of granular and fibrous materials. Although these final chapters summarize the most widely-known facts in this field, they are well worth reading, since they contain many new facts and approaches of considerable value for those who deal with feeding. Previously, machines for cutting and chopping have been deduced and designed on the basis of technical aspects rather than from a knowledge of material parameters.

One of the greatest merits of this book is the extensive list of references, from which it is obvious that the author has based his opinion not only on his own long years of research experience, but also on a large number of papers published throughout the world. It also means that those experts who wish to make a more detailed study of the subject in question are provided with an excellent guide to sources from which they can expand their knowledge.

The book on which this English edition is based was first published in Hungarian, with a similar title, in 1981. The Academy Press deserves great praise for undertaking the publication of this excellent, fundamental and significant work in English, so that experts involved with agricultural mechanization and machine design in many parts of the world can study and utilize the knowledge it contains. J. Karai

C. Barry Nestel: *Development of Animal Production Systems.* Neimann-Srensen: World Animal Science series, No. A-2.: Basic information. Elsevier Publishing House. Amsterdam–Oxford–New York–Tokyo, 1984. 435 p.

Millions of people are now starving and this number is expected to increase with the rapid growth of population, mainly in the developing countries, and primarily in Africa. To combat hunger and malnutrition one of the most important tasks is the development of animal production, for which, among others, we must have recourse to ecology and ethology from the new branches of science. The Elsevier Science Publishers undertook to publish the scientific results of the topic. Many noted researchers took part in the work of exploring the possibilities offered in raising meat- and milk-purpose cattle, sheep, pig, horse, buffalo, poultry, and several newly domesticated or halfdomesticated species.

This book is divided into four main parts, the chapters of which offer sufficient insight into the present state and future propsects of the subject.

Part I examines some major factors which fundamentally influence the success of animal production in various regions of the world.

Chapter 1 (B. Nestel) discusses general questions of animal production, such as land use, animalsustaining capacity of the area, problems of veterinary hygiene, marketing, and maintenance technology.

Chapter 2 (M. H. Butterworth) deals with some foremost tasks of land use, primarily grassland management, — cultivation and — utilization on the different continents. Management problems of wild animals (elephant, zebra, kaffir, etc.) and utilization questions of tropical hunting areas — game preserves — are also mentioned.

Chapter 3 (R. S. Temple and I. Reh) discusses the numerical distribution of domestic animals (cattle, sheep, goat, pig, camel, buffalo, poultry) per continent, and the role of environmental biological and human factors influencing the number and maintenance of animal populations.

Chapter 4 (P. R. Ellis): the effect of veterinary control on animal production is shown. This chapter also deals with the question of disease susceptibility, and with the effects of various pathogens and climatic factor which predispose to or cause diseases. It discusses the role and importance of a veterinary control exercised in the course of shepherding under nomadic and settled conditions, as well as in such other systems of livestock management as intensive animal production. Organization and development problems of the veterinary service, and questions of veterinary hygiene planning, are also got forth.

Chapter 5 (H. J. Mittendorf and N. Krostitz) handles the marketing questions of animal products. The authors discuss first the trends of meat consumption and meat supply worldwide and in each continent, the organization of meat markets in the developed countries, and the special problems of meat supply for the developing countries. They then anylse the demand for and supply of milk in the developed and developing countries.

Chapter 6 (P. Mahadevan) concerns the subject of education for animal breeders and traders, with special regard to the application of various new technologies for farms carrying on traditional shepherding as well as for small and large livestock farms. He touches upon the necessity of developing the milk- and meat production and adapting advanced production technologies, and upon the role and qualification of inspectors (agents) working in this field under the conditions of livestock farms in the developed and developing countries.

Part II describes the animal production systems of the different continents and regions within them.

Chapter 7 (B. Nestel) provides a general comprehensive survey of how animal products are managed in various regions and countries.

Chapter 8 (D. E. Faulkner) discusses the ecological characteristics of the Near-East and Pakistan, the sheep-, goat-, cattle-, buffalo- and camel keeping methods under nomadic and settled conditions, the level of production, the demands for food and the strategy of development.

Chapter 9 (D. J. Pratt) tells of the natural conditions in the arid zone of Africa, with its wild and domesticated livestock, its traditional grazing method of livestock farming, and its development strategy.

Chapter 10 (B. Nestel) outlines the present situation of agricultural production in India, also the number and composition of its livestock. A special section is devoted to the situation and importance of cattle-(zebu-) and buffalo keeping and to the level of their production. The author emphasizes the priority of these species as draught animals. It is mainly among the landless people of the Himalaya region that sheep- and goat keeping has become widespread. A similarly important role is played in India by about 19 goat breeds specialized for milk- and wool production. The chapter acquaints the reader with the question of household poultry farms consisting of barnyard fowl as well as with the management of those poultry farms that include imported cultured layers. The author also presents the situation of meat- and milk production, meat- and dairy industry and of meat- and dairy prices. Some major characteristics of the services related with animal production, such as veterinary service, livestock agency, artificial insemination, research, education and training, state- and co-operative milk collection systems are also discussed. Finally, the author briefly reports on the Indian development programmes of animal production, including the tasks of five-year plans for this purpose.

Chapter 11 (B. Nestel and L. S. Castillo) reviews the animal production systems of South-East Asia and Japan. The authors mention poultry farming as the most important branch, in which chicken, duck, goose, turkey, guinea-fowl, pigeon and quail play equally important roles. In this region, Japan is the main poultry producer. The emphasis upon poultry production in Japan is due to the demand of its population for animal protein which cannot be fully satisfied by beef, pork and milk. The authors also tell of the high level pig and cattle production and the long-term development strategy of livestock farming in the region.

Chapter 12 (V. A. Oyenuga and B. Nestel) specifies the situation and tasks of livestock farming in humid Africa, shows the origin and history of animal production in those regions, discusses the conditions of keeping cattle, sheep, goat, pig and poultry and analyses their productivity. The authors deal in detail with two beef-cattle breeds: a local one called N'Dama which appears most important in the region, and an imported shorthorn beef-cattle, but also explains the importance of other cattle breeds, including the zebu crosses. They describe the major sheep and goat breeds and a local pig breed called "West-African". The role of mostly European cultivated pig breeds used for breeding is briefly mentioned. Bantam is one of the major poultry breeds, but the question of importing upto-date poultry hybrids is also discussed.

Chapter 13 (F. J. Peritz) applies to the animal production systems of South-America. After outlining the ecological characteristics of South-America and the history of livestock farming there, the author concentrates upon questions of cattle-, sheep-, goat-, llama-, alpaca- and pig farming. By using tables, he illustrates the distribution of the cattle stock among the larger countries of the region, its rate of reproduction, the (extremely low) milk- and beef production; the distribution of sheep, goat and pig by area and breed and the level of their production. Information on the extensive, semi-intensive and intensive pig breeds and crosses kept on the continent, on the main keeping, fattening and sometimes very peculiar feeding methods, as well as on the slaughterweights, is likewise depicted in a tabulated form. The latest oil prices and the resulting economic crisis have brought the question of animal production based on uncultivated and on properly fertilized intensive grasses into prominence.

Chapter 14 (J. de Alba) is restricted to the animal production systems of Central America, Mexico and the West Indies. After characterizing the ecology of the region and its history of livestock farming, the author speaks about the fodder plants in the mountains of the temperate zone and in the tropical lowlands, about the highly valuable alpine pastures, the major lucerne species grown in the lowlands, of the white clover, the melilot, the so-called kikuyu grass, and of the local problems of Bermuda grass. As for the cattle branch, the author stresses the importance of using the Jersey-, Guernsey-, Holstein-Frisian, the dairy-type Criollo, the Charolais-, Jamaica-, red poll- etc. breeds, as well as the zebu species for crossing. Little reference is made to sheep-, goat- and poultry farming in this chapter.

Chapter 15 (M. Adamowicz) presents the situation of livestock farming in Eastern Europe. The characterization of livestock farming in the European socialist countries is very poor. The results and trends of milk and egg production in these countries between 1950 and 1974 are indicated in tables. Somewhat more particulars are given of the cattle and sheep branch. The situation of pig farming is almost completely ignored and no information appears on poultry keeping. Comparisons are drawn between the countries for the major methods of state- and cooperative livestock farming, though unfortunately only on the basis of 1975 data.

Chapter 16 (R. E. Hodgson) details the animal production systems of the United States and Canada. After a historical review the registration system and breeding control are discussed. Information is provided of the co-operation of administrative organs, animal breeding organizations, university and research institutes in developing the systems of animal production. The author analyses the difficulties of a market oriented animal production under the highly fluctuating economic conditions of the capitalist countries. Tables illustrate how working hours required to produce unit quantities of animal product in the United States decreased between the periods 1910 to 1914, and 1971 to 1973. Labor time shrank nearly to one-third in beef porduction, almost to a quarter in pork production, and to less than one-sixth in milk and egg production between the two periods mentioned. Production of unit amounts of turkey- and broiler chicken required one-thirtieth of the working hours in the latter period from that of six decades earlier.

Chapter 17 (C. Thomsen) deals with livestock farming in Western Europe. This region that enjoys the benefits of the temperate zone shows a rather wide geographical variation. The mountainous conditions of Norway are difficult to compare to those of Holland or France. In the section on economic history the role of Romans, Germans, Vikings and of the migratory peoples in introducing and acclimatizing the various animal species is explained by the author. A table indicates the volume and distribution of animal products in Western European countries in comparison to their products of plant origin. The well-known European cultured breeds are but briefly mentioned. The author discusses the influence of socio-economic factors (consumer's demand, state control, social circumstances) on the production of animal products, and finally outlines the future perspectives for the development of animal production systems in Western Europe.

Chapter 18 (L. J. Peel) is written on livestock farming in Australia, New-Zealand and South Africa. After the historical section the author only deals with the questions of cattle- and sheep farming in the region. He describes the importance and effect of introducing the Hereford, Ayshire, Jersey and Frisian cattle breeds in the one-time — mostly English — colonies. In the development of the present structure of sheep breeding the author emphasizes first of all the role of many merino breeds and types introduced in the region. The chapter deals in detail with the importance and effect of grasslands and grazing in this vast region.

Part III. Some major causes of recent changes taking place in the animal production are set forth.

Chapter 19 (B. Nestel) pertains to the development strategies. After analysing the intensive system of poultry keeping, the author suggests that the peculiar production systems of Israel, Holland and India become modells for the development of milk production. On the subject of beef-cattle farming he promotes the use of grasslands to extend the possibilities and importance of utilizing legume plants and their by-products.

Chapter 20 (H. F. El-Issawi): Poultry production in the Near-East is described, namely

(1) production based mostly on private initiation and influenced by the state only to a minor extent (Lebanon);
(2) mostly state controlled management with minor private participation (Egypt and Iraq);
(3) production system launched by the state but turned over to the private sector for management (Katar, Oman).

Chapter 21. (Y. Kislev, M. Meisels and S. Amir) reports on dairy management in Israel. The main subjects are: agriculture, milk production before 1948; the methods of development since 1949; research and breeding work; composition of milk as influenced by feeding methods; production technology and specialization; milk consumption; official control.

Chapter 22 (W. J. Joosten and E. G. Kloosterman) deals with the system of livestock farming on the areas of Holland newly reclaimed from the sea and marshes. The major subjects are: the Zuyder-lake plan; the process of reclamation; milk production on the polders; fodder management; animal production systems; farmers' organizations.

Chapter 23 (B. Nestel) tells about the conditions and results of buffalo-milk production, and about the organization frames of buffalo keeping in India.

Chapter 24 (H. S. K. Nsubuga) details the conditions and development plans of cattle farming in South-Western Uganda.

Chapter 25 (R. L. Burt) describes a new type of grassland management and purposeful utilization of papilionaceous fodder areas in tropical regions of Australia.

Chapter 26 (M. J. Creek) deals with the situation and development possibilities of beef production and meat industry in Kenya.

Chapter 27 (T. R. Preston) outlines new possibilities and methods of feeding in the tropics, considering the relatively high energy- and low protein contents of the tropical fodder crops. The utilization of NPN matters and by-products is necessary for the development of ruminant maintenance. The reader learns of several practical feeding programmes for tropical conditions (cattle feeding based on grazing, further on molasses-, sugar cane-, banana-, etc. consumption).

Part IV. Offers insights into the future.

Chapter 28 (C. R. W. Spedding) relates to new matters of curiosity in livestock farming, with special attention to increasing the efficiency of production. In the case of phytophagous domesticated mammals the author writes mainly of the possibilities offered in keeping poultry and carnivorous mammals are also mentioned.

The editor finally summarizes the major stations in the scientific careers of the authors who contributed to this publication.

Recommandation. The book very usefully surveys the situation and development possibilities of livestock farming all over the world. The work is recommended first of all to those professionally engaged in education and research of animal breeding, feeding, ethology and ecology, in the organization of livestock farming, as well as to those who deal with questions of breeding policy and agricultural economics, and also with the problems of tropical farm management.

I. Herold

Progress in Botany — Structural Botany, Physiology, Genetics, Taxonomy, Geobotany, Vol. 48.

Editors: Behnke, H-D., Esser, K., Kubitzki, K., Runge, M., Ziegler, H.

Springer Verlag, Berlin–Heidelberg–New York–London–Paris–Tokyo, pp. 443. Illustrations 16.

The 6 sections of the volume contain contributions by 37 authors. The main sections are as follows:

(A) Structural Botany, p. 1–55;
(B) Physiology, p. 56–214;
(C) Genetics, p. 215–265;
(D) Taxonomy, p. 266–346;
(E) Geobotany, p. 347–387;
(F) Special Topics, 388–444.

Each contribution is compiled on the basis of a vast number of scientific citation providing a broad as well as comprehensive review of the respective scientific domain.

Section A contains chapters on General and molecular cytology, Cytology and morphogenesis of the procaryotic cell, Cytosymbiosis.

Section B focuses on the physiological aspects of plants, i.e. Plant water relations; Mineral nutrition sources of nutrients for land plants from outside the pedosphere; Photosynthesis, carbon metabolism: by day and night; Metabolism of organic N-compounds; Regulation of sulfur metabolism in plants; Secondary plant substances: Monoterpenoid indole alkaloids; Growth: auxins and ethylene; Developmental physiology; Gravi- and phototropism of higher plants.

Section C deals with important genetical aspects such as Replication; Recombination; Function of the genetic material; Extrakaryotic inheritance; Phytopathology.

Section D examines taxonomic questions of lower plants and contains four chapters: Systematics and evolution of the algae; Taxonomy and phylogeny of fungi; Systematics of lichenized fungi; Systematics of the *Pteridophytes.*

Section E. on Geobotany contains three contributions: The history of the flora and vegetation during the Quaternary; Vegetation Science; Ecological geobotany/autecology.

Section F on special topics contains two reviews on physiological aspects: Xylem: structure and function; Symbiosen.

The volume is an extremely rich source of information for all those interested in the latest achievements in botany. The nearly 1000 items of the Plant name index and Subject index facilitate access to all major topics. All in all, the latest volume, No. 48, of Progress in Botany [Fortschritte der Botanik] is – true to the traditions of the Springer-Verlag – an indispensable reference book of great value for botanical research.

Á. Máthé

JONATHAN BROWN: *Agriculture in England* (A survey of farming, 1870–1947) Manchester University Press, 1987

The author analysed a large amount of literature and drew his conclusions with scientific thoroughness. He did not survey the British agriculture from an agrotechnical or zootechnical viewpoint, but from the economical. Reading his book one can see how undulating this development had been, how it was exposed to the world market and world political situation.

The research begins with the 1870's and deals with the period in England when the farmers began to use more up-to-date methods. Roughly during a half century, they abandoned the single-crop corn growing, particularly because of the depressed wheat prices and the low yields. In lieu of this the grazing area increased and the pastures enlarged, from 12 million acres to over 15 million acres. At the same time the acreage of wheat decreased almost by half: from 3 million acres to 1.7 million acres. The feedingstuff cereals — especially barley and oats — gained in area or remained at level. Parallel to this, the sheep husbandry flourished, as the most profitable branch of breeding. There were, however, heavy sheep diseases in 1879 and the ensuing years. Therefore the former stock of 23 million could never again be achieved. In 1914 only 17 miliion sheep remained.

Notwithstanding, the cattle stock grew and the plant production became more varied. Thus formerly often neglected potatoes were grown, along with more and more horticultural crops and fruits. The well developed agricultural background had a strong significance for England during the First World War, although at that time a great supply of food had to be imported.

The world crisis during the 1920's harmed the entire country, including, of course, its agriculture. After the collapse of the Exchange in the U.S.A. the situation quickly deteriorated and many farmers became bankrupt. Those who survived could not even pay the former wages. Strikes followed oneanother and the trade union movement struggled desperately with the landowners. The balance was recovered only in the 1930's. Meanwhile some branches, such as the dairy production, were raised to a higher level and the poultry production grew. Curiously, the poultry branch did not become an integral part of the farms, but expanded as a farm-independent activity. The productivity of agricultural labour also grew, although slowly. The level of 100 points labour productivity of the yeras 1937/39 increased during 1944/45 to 109.

Here the study ends — which this reviewer considers a pity. It would be of great interest to learn how English agriculture continued to develop afterwards, with special regard to the post-war period.

The book, however, can suggest many useful thoughts for the Hungarian reader. Perhaps there is a stimulus, too, for undertaking a similarly thorough research, as far as the agriculture of our country is concerned. A good opportunity exists today, while our current history reveals more objectively the background of past events, and while the development of our agriculture could be analysed by more pragmatic methods.

The book presents a slight difficulty; since the author did not use identical measures, the reader has to work heavily to understand many comparisons. Apart from this fact a good lesson can be drawn from the general English trends.

Above all there are to be seen all of those difficulties that a "left alone" agriculture is obliged to defeat and how many gaps are to be bridged. All these contradictions are emphasized by the author, perhaps as an edification for the future.

I. DIMÉNY

TARJÁN, GÁBOR: *Everyday tradition.* Mezőgazdasági Kiadó, Budapest, 1984.

This well-designed book of 17.5 (A_5) format satisfies every demand. The cover was designed by László Szücs. The six chapters discuss ethnographic questions and each of them gives simple and clear illustrations of their topics.

In the introductory chapter "Present and Future of Folklore" the author speaks of how man in a modern industrial society has lost connection with the small communities and has become impersonal for the sake of profit. Attention has recently turned to the tribal and national traditions in the hope that the old familiar atmosphere will return and continuity with the past will be restored. In Hungary interest in the disappearing requisites of a peasant past began to increase in the 1970's. The fear of this loss of tradition led to the collecting of earthenware pots, embroideries, homespuns, and the learning of ancient crafts. Today it is no longer disputed that our folklore holds values.

The first chapter "The Table Laid by Nature" outlines the conditions under which the productive economy developed and replaced the less safe gathering economy. The detailed list of the foodstuffs collected, especially the description of leaves and flowers used as medicine and of aromatic plants, impart useful knowledge for today. The different methods of storage (desiccation, jam making, milk processing) are highly instructive; bread-baking, the forgotten methods of making drinks, the development and manufacturing of tableware are very interesting items of reading.

The second chapter "From Head to Foot" contains the history costume, and describes the forms and manufacturing of leather clothing and shoes. In addition, we can read about the diversity of processing plant fibres and wool, and about the fashions of hairdressing and matters of personal hygiene.

The third chapter "The Space of Community" surveys the history of home building from the underground dwelling-places in the Arpadian age through the shack, hut, tent, yurt, earthen house, etc. to the present century's village buildings. The reader is informed of the furnishings of the living room, kitchen and larder and with their composition.

The fourth chapter "The All-Knowing Hand" describes the techniques and tools once used for making fire, and working stone, metal and wood. The reader learns the "secrets" of basket-making and weaving, the facilities of land- and water communication and their development. We discover too how our ancestors made use of the forces of nature in operating ship-mills and windmills.

The fifth chapter "Life Under the Sun contains many interesting pieces of information on the ancient explanations of cosmology meteorology. We learn how our ancestors predicted good weather, rain, drought, frost, etc. We are acquainted with the beliefs concerning the heavenly bodies and with the most ancient methods of chronometry.

The sixth chapter "The Calendar" enumerates the major name-days (from January to December) and the traditions connected with them.

The book is concluded with a list of relevant literary works.

This extremely interesting book by Gábor Tarján is warmly recommended to everyone interested in the past and in the popular traditions, in the hope that it will help the reader to realize the importance of folklore. This will increase the sense of community identity of interest, and mutual solidarity which may be one of our strongest supports against estrangement.

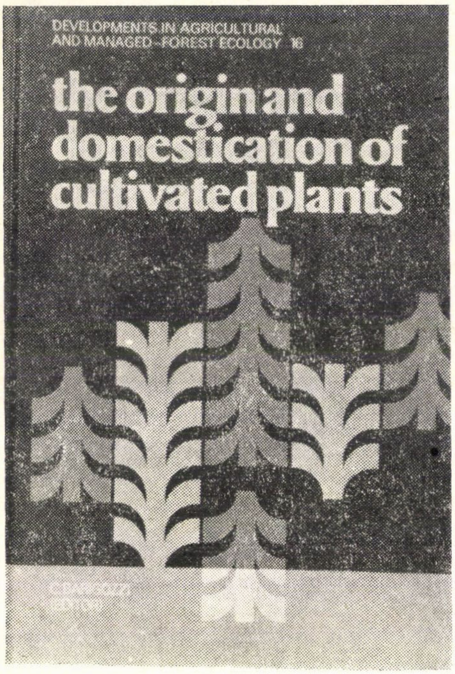
I. Szalai

Developments in Agricultural and Managed-forest Ecology (Ed.: C. Barrigozi). Elsevier Science Publishers Amsterdam–Oxford–New York–Tokyo 1986.

In 218 pages with 56 illustrations this book contains the material of 13 lectures delivered at a symposium in Rome from november 25 to 27, 1985. Briefly, the titles and contents of the lectures are as follows: D. Zohary (Jerusalem): *Origin of agriculture and its distribution in the Old World.*

The author traces the distribution and cultural evolution of cereals and fruit species from 8000 BC in Western Asia, Europe and Africa north of the Sahara. His statements are based either on studies of plant remains found during archeological excavations, or on his analysis on the relationship between currently cultivated plant species and their wild ancestors. J. R. Harlan (Urbana, I 11): *Domestication of plantsv diffuse origin and distribution*

The author calls attention to a flexible interpretation of Vavilov's theory of the centres of origin. He points out that many



cultivated species do not have well-definable centres of origin, while in a number of geographically separated places they show equally high variability, which the author considers a proof of the diffuse origin.

M Hopf (Mainz): *Archeological proofs of the distribution and utilization of some species belonging to the legumes*

Histological methods of identifying seriously damaged leguminous seeds four to ten thousand years old are described, then detailed information is given of the distribution and importance of 8 species.

G. Kimber (Columbia, MO): *Use of models in studying the evolution of alloploids*

After a theoretical and practical analysis of the applicability of models, 12 figures representing various levels of relationship in the *Triticum* genus are shown.

L. L. Cavalli and Sfroza (Stanford, CA): *Influence of agriculture on the growth of the human population*

The spread of agriculture and the growth of human population, since the Neolithic Age, first in the Near East, then in Europe, are discussed. According to the author, the spread of agriculture is the result of a so-called "cultural" growth independent from the growth of human population.

M. Feldman, G. Galili, and A. A. Levy (Rehovot): *Geneticand evolutionary aspects of the polyploidy of wheat.*

The phenomena of internal diploidization (inactivation) and gene dosis compensation (reduced gene expressivity) are shown on the model of alloploidy in wheat. The author produces evidence that all this inner regulation is not the result of a chance process (mutation), but is controlled by many non-specific posttranscriptional factors.

E. Otaviano (Milan), and D. L. Mulcahy (Amherst, MA): *Gametophyte selection as an evolutionary factor in cultivated plants*

The author analyses the effect of gametophyte selectrion — and, within this, the effect of selection acting on the pollen grain — together with and in comparison sporophyte selectrion, primarily with maize as a model.

J. Brace (Manchester): *DNA of cultivated plants and their wild relatives*

The author points out that the DNA of closely related plants may be very different both in quantity and in the arrangement of DNA sequences within the genome. While attaching little evolutionary importance to the repetitive DNA sections he consifers the structural rearrangement of chromosomes important together with the specific change of genes.

I. Wahl and A. Segal (Tel Aviv): *Evolution of host-parasite relationship in the natural indigenous population of wild barley and wild oat in Israel*

Through the natural relationship between the *Avena* sp. and *Puccinia* sp. and between the *Hordeum* sp. and *Erisyphe* sp. the author demonstrates the development of a ba anced polymorphism resulting from a mutual selective pressure.

E. Porceddu and D. Lafiandra (Viterbo): *Origin and evolution of wheat*

Detailed data are presented on the origin of the AABBDD genomes and on the distribution of species carrying these genomes.

P. Hanelt (Gatersleben): *Evolution of legumes and vegetables*

The evolution of cultivated plants is characterized by the example of species of minor importance: *Lupinus* sp., *Vicia* sp., *Allium* sp. and *Raphanus* sp.

P. Spiegel Roy (Bet-Dagan): *Domestication of fruit species*

The author shows the changes having taken place during the 6000 year domestication of the most important fruit species.

P. D'Amato (Pisa): After a summary of the lectures delivered at the symposium the author provides his description of the spontaneous mutations that form the basis of evolution.

P. Muzik

Spaar, D., Kelinhempel, H. and Fritzsche, R.: *Diagnose von Krankheiten und Beschädigungen an Kulturpflanzen, Gemüse.* Springer-Verlag Berlin, Heidelberg, New York, Tokyo, 1986.

This 406-page volume of the series "Diagnosis of diseases and pests of cultivated plants" deals with the pests of vegetable crops. The book was published by the Springer Publishing House and the authors ar members of Scientific Institute in the German Democratic Republic.

The book describes the pests of these vegetable crops: cabbage, radish, horse radish, peas, bean, tomato, paprika, egg-plant, cucumber, melon, vegetable marrow, spinach, red beet, chard, lettuce asparagus, black radish, onion, carrot, celery, parsley, rhubarb, and mushroom.

The first part of the book is a key to pathogens and pests occuring on vegetable crops: and it assists in identifying them on the basis of symptoms observed on various plant parts.

The second part of the book contains descriptions and pictures of the diseases and pests. Identification is made easier by 151 coloured plates which present micro- and macroscopic drawings of the pathogens and pests in addition to the damages caused by them. Identification after the plates is further facilitated by the representation of each vegetable species.

Finally the scientific and German names of the pests are given.

The book is recommended to those engaged in plant protection or cultivation. With its aid the damage can be identified, and with the cause of the damage known the method of control can be properly chosen.

M. Glits

Szabó, S. S., Regius-Mőcsényi, Á., Győri, D. and Szentmihályi, S.: *Microelements in Agriculture. Essential Microelements.* Mezőgazdasági Kiadó, Budapest, 1987.

This book provides information about the changes of the concentration of the various microelements occuring in food-chains, and about the factors influencing the microelement migration, — transport and accumulation.

In the *first chapter* the definition of the conceps of microelement is determined. A new concept is introduced: the stimulative microelement. Examples given in the chapter mostly relate to animal organisms. A few pages devoted to the methods of determining microelements, though owing to its importance this question would have been discussed in greater detail, even at the expense of the other parts of the chapter.

Chapters 2 to *7* are devoted to the essential microelements in the following order: Mn, Zn, Fe, Cu, Mo, B. Each chapter deals with its subject in the same way: the element concerned in the soil, in the plant, in animal products, and in foods. Spec al attention is paid by the authors to the role of the different microelements in plant physiology, to the element content of plants and the factors acting on it, and to the optimalization of the microelement status of plants. The chapters treating different elements also deal with the role of the respective elements in the metabolism of animals, discuss the element content of feedstuffs and the factors influencing it, analyse the microelement status and the production of animals. The element content sof foods are shown in tables. Each chapter is concluded with a short summary of the subject treated.

In connection with the element contents of soils the authors discuss the quess on of availability and metnion the factors that act on the biogenic circulation of the individual elements. They call the researchers' attention to the importance of measuring the ion activity, since the ion concentration is practically a value of no use in such a complex system as the soil solution. It should be noted that in nutrient solution the decreasing activity in the case of Cu, Fe and Zn is demonstrably due to the presence of PO_4 which prevents the absorption of the elements on the surface. As for the heavy metals, their occurrence in an organic form is no negligible factor. Their uptake by the cell is a question that remains to be cleared.

Plant physiology implications of the microelements are mentioned briefly, the element content of plants and the factors which influence it, as well as the optimalization of the microelement status, are discussed in some detail. The chapters that deal with the microelement requirements of animals and the ways of the microelement supply include the material in well demonstrated tables and — in addition — give a full list of the relevant literature.

Chapter 8 discusses the optimum supply of microelements in regard to both plants and animals. Suggestions are made on how to replace and supplement the microelements. The microelement contents of foods in Hungary are shown in a table.

The book concludes with a terminological vocabulary and a bibliography. The literature is divided in three parts; one for the Hungarian-, one for the Russian citations, and one for those in other languages.

We hope that this book will call the readers' attention to the complexity of the question of microelement status, as well as to the dangers of microelement deficiency and — overapplication.

EDIT CSEH

PRINTED IN HUNGARY

Akadémiai Kiadó és Nyomda Vállalat, Budapest

AUTHORS' GUIDE FOR MANUSCRIPT PREPARATION

GENERAL INSTRUCTION

Two copies of the manuscript and two sets of the figures should be submitted to:

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H-1118, Budapest

Manuscripts in English or in Hungarian including Abstract, References, Tables and Legends should be typed double-spaced (25 lines, 50 characters per line including spaces) and supplied with authors' names, page number. Tables should be on separate, numbered pages after the References. Legends for figures, on a separate page, should follow the tables. Standard articles should not exceed seven pages.

FORMAT

Title. The title should reflect the most important aspects of the article, in a preferably concise form of not more than 100 characters and spaces.

By-line. The authors' names should be followed by affiliations and addresses. (No inclusion of scientific titles is necessary.)

Abstracts are required for all the manuscripts. They should be typed in one paragraph and limited to max. 200 words. Below the abstracts, an alphabetical list of keywords should be given.

Text. Major sections after the introductory statements are: *Material and methods*, *Results*, *Discussion*, *References*. Subheadings may be used, though the unnecessary fragmentation of the text should be omitted.

Style. After acceptance for publication, manuscripts are reviewed for style, grammar and clarity of presentation.

Units should be conform to the International System of Units (SI).

Authors can facilitate editing work by indicating in pencil, the precise meaning of certain symbols (e.g.: distinguish O from zero, the number 1 from the letter "l", the multiplication $\times$ from letter X).

Names. Underline Latin binomials to indicate italic type.

Figures. Line-drawings should be clear and of high quality. Cite all figures in numerical order in the manuscript. Captions should describe the contents so that each illustration is understandable when considered apart from the text. Each illustration should be labelled with the figure number, author's name, and Acta Agronomica.

High-quality glossy prints of photographs should be cropped at right angles to show only essential details. Insert a scale bar where necessary to indicate magnification. Submit two sets of prints of equivalent quality.

Tables. The title should be self-explanatory and include enough information so that each table is intelligible without reference to the text or other tables. The title should summarize the information presented in the table without repeating the subheadings. Subheadings should be brief (abbreviations are acceptable) nonstandard ones can be explained in footnotes. Cite tables in numerical order in the manuscript. Information presented in a table should agree with that in the text.

References. List literature cited in alphabetic order by authors' surnames. The list should contain names and initials of all authors (et al. is not accepted here); for *journal articles* year of publication, the title of the paper, title of the journal abbreviated (do not abbreviate one word titles), volume number, first and last page. Russian titles should be transliterated and Hungarian titles translated in parentheses.

For books or chapters of books, the titles are followed by the publisher as well as place and date of publication.

Examples:

Kis, Gy., Papp, I., Bakondi-Zámori, É., Gartner-Bánfalvi, Á. (1977): A szója fungicides magcsávázásának és rhizóbium oltásának együttes tanulmányozása (Joint study of fungicide dressing and rhizobium innoculation in soybean). Növénytermelés, **26**, 147–153.

Zinovev, L. S., Matalova, T. S. (1976): Protaviteli, bezopasnie dlya klubenykovykh bakterii. Zashchita Rastenii, **5**, 29–31.

Mather, K. and Jinks, J. L. (1971): Biometrical genetics. Chapman and Hall Ltd., London, U. K.

Index: 26.001